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Aquatic Habitat Appraisal Guide

User's Manual

*by Dean Mathias, Blue-Six Software, Inc.
Thomas B. Hardy, Utah State University
K. Jack Killgore, WES
Joseph W. Jordan, U.S. Army Materiel Command Installation
and Services Activity*

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User's Manual

by Dean Mathias,

Blue-Six Software, Inc.
13 Fairway Lane
Logan, UT 84321-5961

Thomas B. Hardy

Utah State University
Logan, UT 84322

K. Jack Killgore

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Joseph W. Jordan

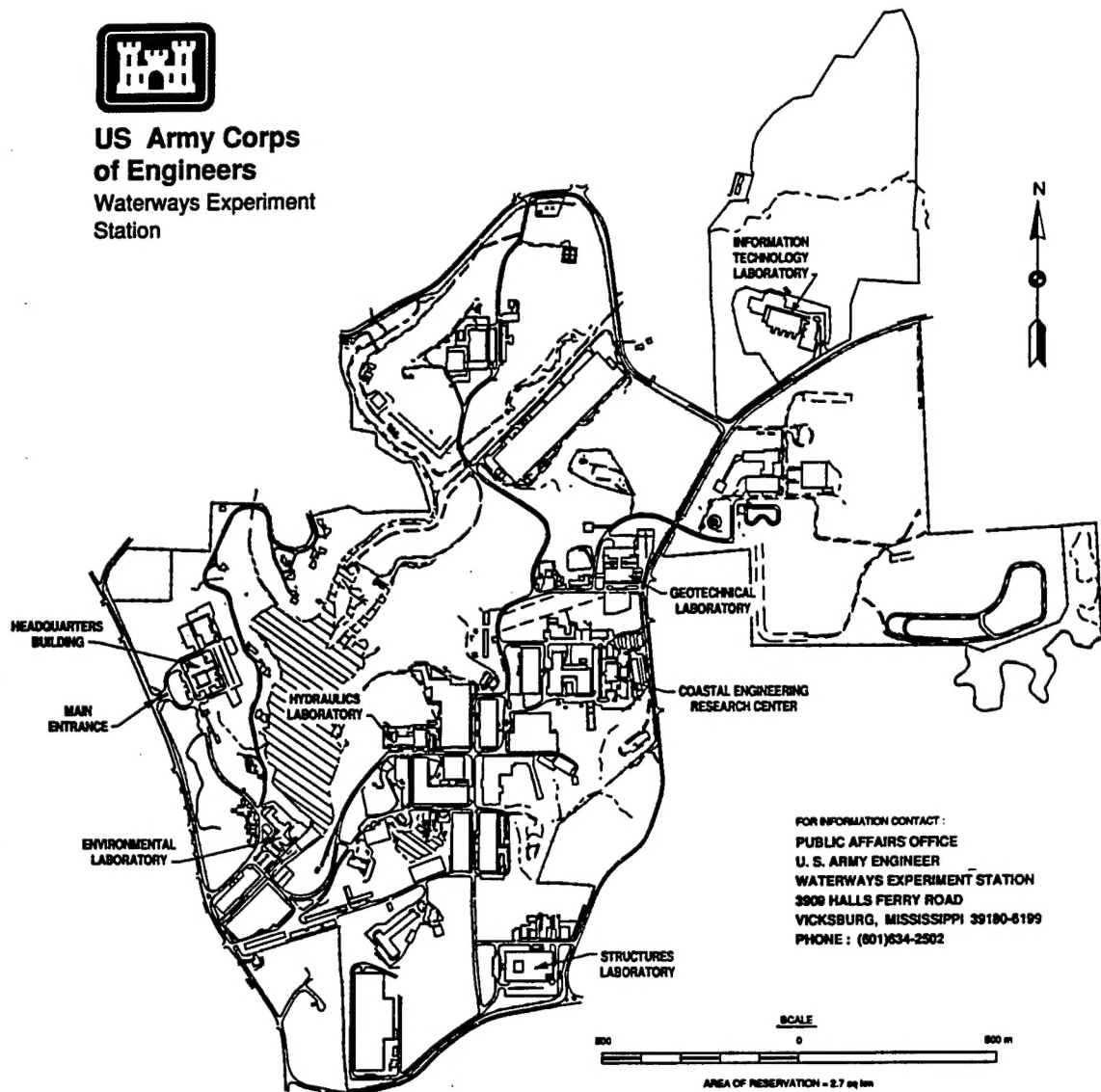
U.S. Army Materiel Command Installation and Services Activity
Environmental Compliance Division
Rock Island, IL 61299-7190

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Preface

The Environmental Management Program (EMP) was established by Congress to protect and manage biotic resources of the Upper Mississippi River System (UMRS). As part of EMP, Habitat Rehabilitation and Enhancement Projects (HREP) were planned for specific areas in the UMRS. These projects will be constructed in large rivers of the UMRS and include removal of sediments from backwaters, placement of water control structures to manage water levels in backwater areas, and restoring flows to side channels. Approximately 100 HREP projects are planned for the UMRS, each project taking 1 to 2 years to complete. A habitat evaluation of each project is required to document environmental benefits and assess alternative project design features. Consequently, an Aquatic Habitat Appraisal Guide (AHAG) was developed as a planning tool to meet the habitat evaluation requirements of each project. This document explains the development and use of AHAG to evaluate HREP in the UMRS.

Authors of this report were Mr. Dean Mathias, Blue-Six Software, Inc., and Dr. Thomas B. Hardy, Utah State University, Dr. K. Jack Killgore, U.S. Army Engineer Waterways Experiment Station (WES), and Mr. Joseph W. Jordan, U.S. Army Materiel Command Installation and Services Activity, Rock Island, IL. Messrs. Bob Clevensine and Jon Duyvejonck, formerly with the U.S. Army Engineer District, Rock Island, assisted in the conceptual design of AHAG. Dr. Jan Jeffrey Hoover and Mr. Jim Morrow, WES, and Mr. David Gates, U.S. Army Engineer District, St. Louis, provided technical assistance. AHAG was reviewed by fisheries biologists from the U.S. Fish and Wildlife Service, Iowa Department of Natural Resources, Wisconsin Department of Natural Resources, Missouri Department of Conservation, Illinois Department of Natural Resources, and Illinois Natural History Survey. Special thanks to Mr. Matthew D. Chan, WES, for his editorial assistance.

During the conduct of this study, Dr. John Harrison was Director, Environmental Laboratory, Dr. Conrad J. Kirby was Chief, Ecological Research Division, and Dr. Edwin A. Theriot was Chief, Aquatic Ecology Branch, WES.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	0.4047	hectares
feet	0.3048	meters
miles (U.S. statute)	1.609347	kilometers
pounds (mass)	0.4535924	kilograms

1 Introduction

An Aquatic Habitat Appraisal Guide (AHAG) was developed to evaluate fish habitat in the Upper Mississippi River System. AHAG is based on the concept of the Habitat Evaluation Procedure (U.S. Fish and Wildlife Service (USFWS) 1980) and follows the format of the Wildlife Appraisal Guides (Baskett et al. 1980). AHAG is used to numerically rate habitat quality for individual species of fish under varying environmental conditions and to document benefits of environmental features (e.g., creation of slack-water habitat and construction of weirs) incorporated in the project design.

This user's manual provides an overview of AHAG and instructions on using AHAG software. The software integrates Habitat Suitability Index (HSI) scores to calculate Habitat Units (HUs) for each evaluation fish species. Life stage (spawning, rearing, and juvenile/adult), habitat (lentic or lotic), and season can be included in the assessment. The software compares HUs among different project alternatives and places this information into tables or output files.

A default matrix of HSI values for eight evaluation species can be used to calculate HUs or new values can be created. Development of the default matrix is shown in Chapter 10 and includes selection of evaluation fish species and description of habitat variables used in AHAG. Modification of habitat-based models is encouraged to be more applicable for a particular geographical area where different habitat factors may be limiting (Layher and Maughan 1985; Hubert and Rahel 1989). AHAG software makes modification easy, while providing a permanent record of the assessment process.

Overview of AHAG

AHAG is a general planning tool used to rate habitat quality for fish species using the following generalized equation (USFWS 1980):

$$HU = HSI * AREA$$

where

HU = Habitat units

HSI = Habitat Suitability Index that ranges from 0.0 to 1.0

AREA = Area of project site such as acres

Format of AHAG is shown in Chapter 10.

AHAG requires the user to input values of each habitat variable estimated from existing information or measured in the field depending on time and resources available. Predicting future changes in habitat can be accomplished through consensus or application of physical models (e.g., water quality and sedimentation). Although AHAG does not require fish sampling as part of the evaluation, efforts should be made to verify relationships between habitat quality and fish abundance. Only through critical review of AHAG components combined with monitoring studies will the validity of an AHAG output be determined.

Habitat Suitability Index Values

Any variable can be used in AHAG. The default matrix (Chapter 10) uses five types of variables to evaluate fish habitat: physicochemical, habitat structure, morphometric, hydraulic, and interspersed. When selecting variables, consider the following criteria: Each variable may limit the abundance and distribution of the evaluation species, is directly affected by the engineering objectives of the project, is readily measured in the field, and can be predicted for future environmental conditions.

AHAG uses a specific format to display HSI values (see Chapter 10). For each variable, the range of habitat values are divided into classes, and an HSI value is assigned to each class by life history stage (spawning, rearing, and juvenile/adults) of evaluation species. Each class interval is rated as excellent (1), good (0.75), fair (0.5), poor (0.25), or unusable (0) habitat. The AHAG software provides an option of using a continuous relationship (i.e., curve) to determine the HSI value by fitting a curve to the midpoints of each class interval (see Chapter 6 - AHAG Edit Menu).

Normally, a final HSI value is multiplied by a measurement of area (e.g., acres) to obtain HUs. Final HSI scores are obtained using one of the following methods:

- Arithmetic mean of all variable scores (compensatory relationships).
- Arithmetic mean of selected variables that are considered limiting.
- Taking the single lowest HSI score (limiting factor).

Compensatory relationships exist when a variable with marginal or low value is offset (or compensated for) by the high suitability of other variables (USFWS 1980). A limiting factor is used when the variable with the lowest suitability is perceived to be so significant that it overrides all other factors in the functional relationship (USFWS 1980).

Season and Life History Stage

Since habitat use varies by season, AHAG uses a wide range of values for each variable to permit an evaluation of the study area for winter, spring, summer, and fall conditions. Habitat conditions can become limiting to a species during a particular season, such as low water temperature and low dissolved oxygen in the winter. Therefore, HSI scores should be calculated seasonally, and periods when habitat variables become limiting should be emphasized.

AHAG provides a habitat quality rating for spawning, rearing, and adult life stages of the evaluation species. Spawning is defined as deposition of fertilized eggs at a specific location and incubation of the eggs. Rearing is the phase of development from the moment of hatching, through yolk-sac larvae, absorption of the yolk, and ending when a minimum adult complement of rays is present in all fins and the median fin fold is completely absorbed (Wallus et al. 1990). Juvenile/adult stage is when growth attainment is at or near maximum size, an adult complement of rays is present in all fins, and the median fin fold is completely absorbed through attainment of sexual maturity (Wallus, Yeager, and Simon 1990).

For some species or life stage, there are no HSI values for a particular variable. This indicates that this species or life stage does not require this habitat variable for survival and growth. In other cases, there are no low HSI values (i.e., 0 for unusable habitat; 0.25 for poor habitat), indicating that this variable may enhance growth, but is not a necessary requirement for survival of the species or life stage.

Interpreting Model Outputs

Habitat-based assessment techniques make specific assumptions on species-habitat relationships (Terrell 1984; O'Neil 1985). Each assumption may be intuitively correct, but can only be verified from field studies. Typical assumptions are as follows:

- Abundance and distribution of species respond in a predictable and measurable fashion to changes in habitat quality defined by the variables in the model.
- At least one of the habitat variables can potentially influence distribution and abundance of evaluation species.
- Habitat variables represent physical and water quality characteristics of the study area.

Because of limited information on the life history of many species, the influence of competition and predation on habitat preferences, and variation in temporal distribution patterns of fishes, output of AHAG may not represent a causal relationship. Thus, HUs may not be necessarily associated with population density. The proper interpretation is by comparison (USFWS 1980); areas with higher HUs should have the potential to support more fish than areas with lower HUs.

2 Overview of Software

This chapter summarizes AHAG software including a description of each chapter.

<u>Chapter</u>	<u>Content</u>
Chapter 3	Provides information on how to install AHAG and customize the system defaults. Describes the various system level settings and how they can be changed.
Chapter 4	Provides information on how to initiate AHAG and summarizes its features.
Chapter 5	Provides a detailed description on file operations within AHAG.
Chapter 6	Describes procedures to edit various data sets when creating a study.
Chapter 7	Discusses how to view calculations and how they are generated.
Chapter 8	Provides instructions on using different kinds of help within AHAG.
Chapter 9	Describes development and rationale of AHAG default matrices.

AHAG includes the following features to aid in the assessment of aquatic habitats:

- Three predefined default matrices for use in evaluation of aquatic habitats. These matrices include the following species: white bass, emerald shiner, river darter, northern pike, smallmouth buffalo, wall-eye, largemouth bass, and bluegill. For each of these species, three life stages are evaluated in the matrices.
- The ability to define customized sets of species and habitat variables.

- Easy input and customization of the data contained within the HSI matrix.
- Easy and rapid access to output based on the matrices and time period data.

Hardware and Software Requirements

AHAG runs on the IBM PC compatible family of computers, including the AT and PS/2, along with all true IBM 8086, 80286, 80386, 80486, and Pentium computers. It requires DOS 2.1 or higher, a hard disk, a floppy drive, and at least 600,000 bytes of conventional memory available; it runs on any 80-column monochrome or color monitor.

Here is an itemized list of components necessary to use AHAG:

Computer	IBM, or fully compatible, 8086 or better
System Memory	600,000 bytes of available conventional RAM
Hard Drive	At least 2 million bytes available
Monitor	80-column monochrome or color
Graphics	None required, but can use CGA or better graphics
Floppy Drive	One 360K 5¼ or one 720K 3½ (required for installation)
DOS	MS-DOS 2.1 or higher
Printer	Epson or HP Laserjet compatible (not essential)
Mouse	Microsoft compatible mouse (not essential)

AHAG Implementation

AHAG was written completely in C language. It was coded such that future modifications can be easily incorporated into the package. Additionally, the software was written to be "User Friendly" in a way that is natural to the user. This means that items, such as data entry, are implemented in a familiar context such as a spreadsheet type display. The use of menus, function keys, arrow keys, and mouse were also incorporated to aid in the ease of user familiarity of software.

AHAG Package

The AHAG package consists of a single disk (upon request) and this manual as the user documentation. (See Appendix A for software order form.)

Typefaces Used in These Documents

All typefaces used in this manual were produced by WordPerfect for Windows on an HP laserjet printer.

Monospace Type	This typeface represents text as it appears on the screen or in the program. It is also used for anything you must type literally (such as AHAG to start up the program).
BOLD ITALIC	This typeface is used to indicate menu choices that can be selected by using arrow keys followed by a carriage return.
ALL CAPS	This is used for names of files.
<i>Italics</i>	Italics indicate variable input that appears in the document. They can represent terms that you normally use, or any substitution (usually, your choice). They are also used to emphasize certain words, such as new terms.
<KEY>	This typeface is used to identify a key on the keyboard. For example, "Press <ESC> to exit a menu." This example indicates that you must press the Escape key in order to exit a menu.

3 Installing AHAG

AHAG comes with an automatic installation program called **INSTALL**. You must use this program; you cannot just copy the AHAG files onto your hard disk. Instead, **INSTALL** automatically copies and creates additional files for use by the AHAG software.

It is assumed that you are already familiar with basic DOS commands. For example, you'll need to use the **DISKCOPY** command to make backup copies of your distribution disks. Make a complete working copy of your distribution disks when you receive them; then store the original disks in a safe place.

This chapter contains the following information:

- Installing AHAG on your system.
- Information about customizing the default setup of AHAG.
- A pointer to more information on AHAG default matrices.

Using **INSTALL**

INSTALL will create the directories that are needed when installing the AHAG software. It also creates the system defaults file (based on your inputs during installation) and copies all files from the distribution disk to the appropriate directories on your hard disk.

To install AHAG:

- a. Insert the AHAG distribution disk into your floppy drive (We will assume drive A). Type the following commands, with each followed by **<ENTER>**.

A:\INSTALL

- b. Follow the installation program prompts to set system defaults (described below).

The System Defaults menu describes the operating environment for the AHAG software. They are accessed by selecting the *System Defaults* menu choice from within the *Options* menu. When this choice is selected, a window titled System Defaults appears in the center of the screen. System Defaults are edited within this window. See Figure 9 for an example of this screen.

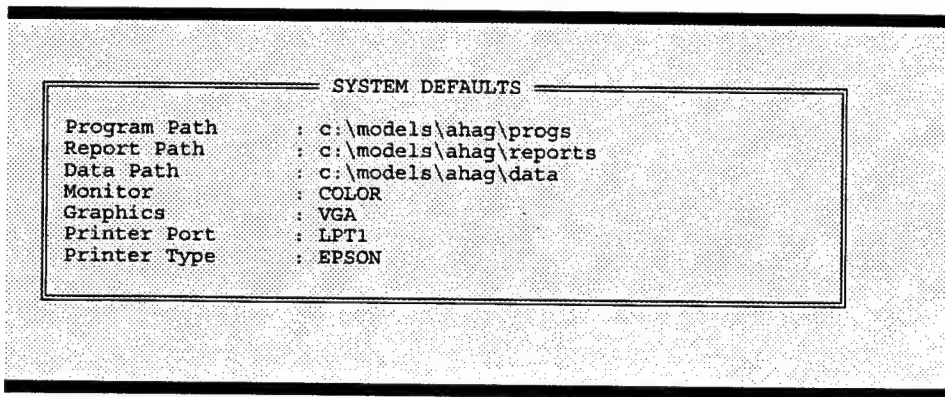


Figure 1. Example of System Defaults screen

These defaults are initially set when installing the program for the first time. However, they can be easily changed. For example, for the monitor type, use the arrow keys to move the highlight bar to the Monitor selection, and use the <SPACE> or <ENTER> keys to switch between the choices. The next section explains each individual default option.

System Defaults

- Program path.

The pathname (drive and directory) to where the AHAG software will reside must be specified. This is used mainly for the installation program. If this directory does not exist, the installation program will create it for you. This option should not have to change once the software is initially installed unless future additions of AHAG are used.

- Report path.

The Report Path (drive and directory) is the location that AHAG will use to save any output requested by the user. A variety of different report directories can be used, but remember that AHAG will send reports to the currently defined report pathname only. AHAG created the report directory C:\AHAG\REPORTS. Additional directories must be created by the user (refer to the DOS manual for more information on creating directories).

- Data path.

The Data Path is the pathname location where AHAG software will search for and save study files. Study files can be stored in any directory, but it is the users responsibility to create directories other than C:\AHAG\DATA and maintain the directory listing within the AHAG system defaults.

- Monitor.

This Monitor option specifies the type of monitor used with the computer that AHAG software is installed upon. COLOR indicates a color monitor (i.e., CGA, EGA, VGA, etc.). MONO indicates a monochrome monitor (i.e., amber).

- Graphics.

The AHAG software will allow the user to graphically view some of the input data used by the models. This option lets the user specify the type of graphics adapter to use when displaying the graphics. The available choices are CGA, EGA or VGA.

- Printer port.

The AHAG software can send reports directly to the printer. In order to make this work correctly, the proper port where the printer is connected must be selected. There are three possible choices for the printer port—LPT1, LPT2, or LPT3. Choose the correct printer port on your computer (most commonly LPT1) for the printing to work correctly.

- Type of printer.

The AHAG software has the ability to send printer data to two different types of printers. This option lets the user specify the type of printer he intends to use with the software. These two types are Epson or HP Laserjet compatible printers.

To change system defaults after the initial installation to the hard disk, select the System Defaults menu choice under the Options menu and the system defaults editor will appear. When finished making changes, press the

<F10> function key to save these options. The changes to the system defaults become active upon returning from this editor.

4 Using AHAG

Running AHAG

To execute AHAG, simply type AHAG (in the AHAG directory), followed by a carriage return at the DOS prompt. The following is an example of this:

```
C:\AHAG>ahag <ENTER>
```

When AHAG is started, the program will display a small window on the center of the screen stating that the program is initializing itself. This will be followed by the main screen that contains the main menu bar across the top of the display. The five menu choices are *File*, *Edit*, *Calcs*, *Options*, and *Help* (Figure 2).

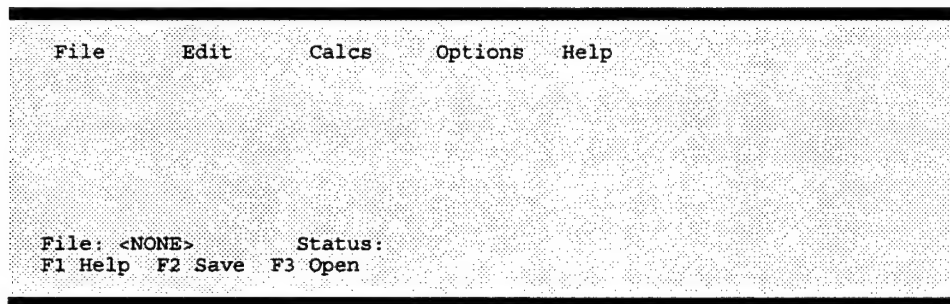


Figure 2. Example of AHAG main screen

The main menu provides access to all program functions. The *File* menu contains all functions related to file manipulation, printing, DOS shell, and exiting the program. The *Edit* menu allows access into the different types of data that can be input into the program. The *Calcs* option tells the program to display the results of the Field Data calculated using the model loaded into memory. The *Options* menu provides access to the system level features of the software such as the program paths and system colors. Finally, the *Help* menu option allows access to the available on-line help.

The function key line indicates which keys are currently available to the user. The line just above the function key line is the status line. The status

line shows the name of the currently loaded study file (and also what additional cursor keys are available for selection by the mouse). Each of the main menu choices are discussed in the next chapters.

Keys Used in AHAG

The following is a list of the most commonly used keys within the AHAG system relating to functions, cursor movement, help, and menu selection.

- | | |
|-----------------------|--|
| <F1> | This function key is always used to invoke the context sensitive help screen at any point in the system. |
| <F2> | This function key is used throughout most areas in the system to save the current study file. It is used in the directory functions to view the header of the current file identified by the highlighted cursor. |
| <F3> | This function key is used to open the directory of data files to be loaded into memory. |
| <F4> | This function key is used while editing in the work sheet to open a pop-up menu to change the type of a cell. It is used in the calculations section to save results of calculations to a file. It is also used in editing system colors to select foreground color. |
| <F5> | This function key is used while editing system colors. It is used to select background color for modification. It is also used to copy a field data sheet value across all target years. |
| <F10> | This function key is used to save System Defaults. |
| <ENTER> | This is the Enter or Carriage Return key on most keyboards. It is used to confirm selections from menus and to perform a variety of other selected tasks. |
| <ESC> | This key is used to exit any current screen or menu option. |
| <Arrows> | These keys are used to move around in the work space and menus. |
| <PGUP> | This is used in various sections of the program to move the cursor up an entire page of data. |
| <PGDN> | This is the same as the <PGUP> key, except it moves the cursor down an entire page of data. |

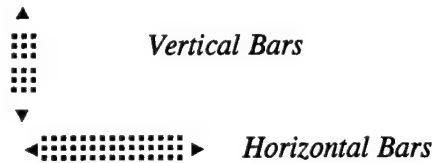
- | | |
|-------------------------|---|
| <HOME> | This key is used to move the cursor to the beginning of a column of data. |
| <END> | This key is the complement to the <HOME> key. It moves the cursor to the end of a column of data. |
| <TAB> | This key is used in the Calculations to move forward through the species and life stages and in other parts of the program to switch between two input items. |
| <Shft-TAB> | This key combination is used in the Calculations to move backward through the species and life stages. |
| <INSERT> | This key is used in various parts of the program to make a new space for input at the cursor location. |
| <DELETE> | This key is used in various parts of the program to delete the currently highlighted selection. |

Using Pop-Up Menus

Pop-up menus are windows that display a series of choices for selection. The menu will contain two or more options for selection. When first encountered, the first option of the menu will be highlighted. This highlight bar can be moved by using the up and down or left and right arrow keys. To make a selection from the menu, move the highlight bar to the desired option and press the **<ENTER>** key.

Using Mouse

The AHAG system supports the use of the mouse for most program operations. In all areas of the program where the arrow keys can be used for cursor movement, there are also horizontal or vertical bars that are used by the mouse to control the cursor movement. Below is an example of the Horizontal and Vertical scroll bars for use with the mouse.



Scrolling in either the horizontal or vertical direction is accomplished by moving the mouse pointer to one of the arrow designations and clicking the primary (usually left) mouse button. Additionally, the mouse can be used to select the function keys on the function key line and other movement keys on the status line. This is done by moving the cursor over the desired key and pressing the primary (left for right-handed users, right for left-handed users) mouse button. While editing an AHAG work sheet, the mouse may be used to position the highlighted cursor and further select that position for detailed editing. In general, the mouse is used much in the same manner as other software that supports use of the mouse.

Editing Text and Data

One basic function of the AHAG software is the ability to input text or data in various sections of the program. In all sections of the program where there are multiple entry fields (Definitions, Work Sheet, and Field Data), the cursor keys can be used to move about the different fields. Once the cursor is located on the desired field to edit, there are two basic ways editing can begin. The first is to begin typing in the new information. When this is done, the previous information is erased and only the new data is accepted for input. The second approach is to first press the <ENTER> key to keep the current information, and only modify it in some way. During editing of the field, the <ESC> key can be pressed to undo any changes already made and have the previous information returned. However, if the current editing is finished, press the <ENTER> key to signal the software to accept the entry and remove the previous data.

5 AHAG File Menu

The study file provides all necessary information on the project used in AHAG software. All AHAG study models are stored using a single file format. This section provides information needed to create a new study, use the default matrices, and load other existing AHAG study files.

The AHAG *File* menu is the first choice on the left-hand side of the main menu bar. From this menu, all of the file operations can be selected, hence the name File. Additionally, options for Printing and leaving the program are also contained within this menu. The first five operations deal with creation, loading, saving, and deleting studies. The next File menu choice allows access to printing functions, and finally the menu to leave AHAG software. Each of the options are discussed in more detail in the remainder of this chapter.

Creating a New Study

All study models are contained within a single file. When creating a new study, the AHAG software creates a new file in the data directory currently defined in the System Defaults (See Chapter 3 for more information about this feature).

To create a new AHAG study, select the *New* menu choice within the *File* menu located on the main menu bar. When this choice is made, the program will ask for a filename with the following prompt:

Enter the filename for this study...
Filename:

Simply type in the desired filename and press <ENTER>. This will cause AHAG to create an empty study template that can be used to fully develop a new study. However, note that this study will not be saved until the users saves it (described below). This template contains the following study parameters:

- 1 Habitat Variable
- 1 Species
- 1 Life Stage
- 1 Histogram
- 1 Target Year

All of the data fields will either be zeroed, contain blanks, or contain the word <EMPTY>. For more information about how to update and edit this template into an AHAG model, refer to Chapter 6—AHAG Edit Menu.

Using Default Matrices

The AHAG software package includes three default matrices that can be used in their current form or customized to meet a specific need. Chapter 10 describes development of the default matrices. The names of these three files are DEFLT1.DAT, DEFLT2.DAT, and DEFLT3.DAT. These three files contain the same Habitat Variables, but represent a series of eight different species for evaluation.

- DEFLT1.DAT
White Bass
Emerald Shiner
River Darter
- DEFLT2.DAT
Northern Pike
Smallmouth Buffalo
Walleye
- DEFLT3.DAT
Largemouth Bass
Bluegill

Follow the directions in the next section on Loading a Study to use any one of these default matrices. NOTE: If the data is changed in any one of these matrices, save that particular study using a different filename other than the default study filename.

Loading a Study

Once a study has been created, edited, and saved, it can then be loaded at a later time for further editing or used to generate calculations. To load an existing study file into memory, select the *Open* menu choice within the *File* menu or press the <F3> function key. When *Open* is selected, the program will present a window with the names of the files that are located in the data

directory as defined in the System Defaults (See Chapter 3 for more information). Figure 3 shows an example of what this screen looks like.

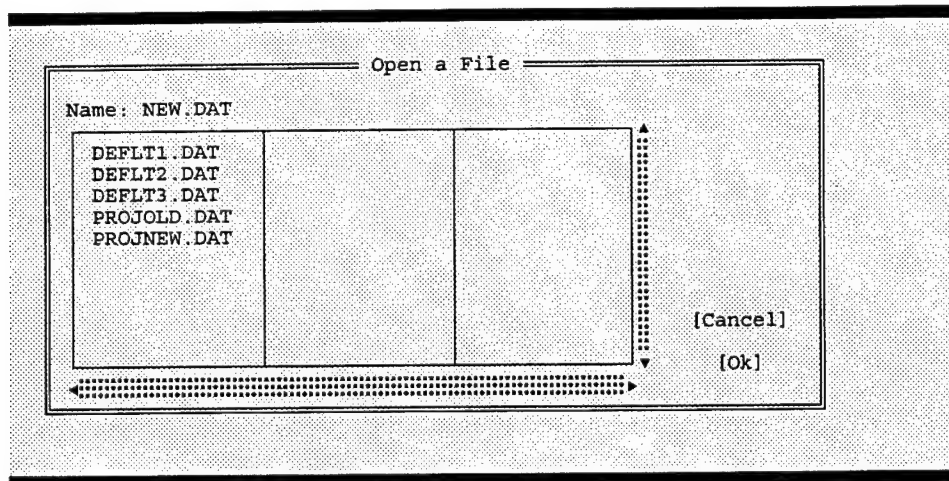


Figure 3. Example of Open a File window

The Open a File window appears in the center of the main AHAG screen when first opened. The main body of this window contains three columns where the filenames in the data directory will appear. The filename currently highlighted in a specific column will also be the filename listed by the heading of Name:. The cursor keys can be used to move the highlighted cursor bar within this window to select the appropriate file for loading. When the correct file is highlighted, press either the <ENTER> key or use the mouse to select the [OK] button on the right-hand side of the window; that file will then be loaded into the program memory. Additionally, it is also possible to type in the name of the file followed by pressing <ENTER> to load a file into memory. Once the file is loaded into memory, the Open a File window will disappear and the filename of the study will now appear on the status line.

Saving a Study

There are two methods for saving a study currently loaded in the program's memory. The first is to select the *Save* (or the <F2> function key) menu choice in the *File* menu or to select the *Save As...* menu choice in the *File* menu. When selecting the *Save* option, the computer responds by saving the study loaded in memory under the filename being displayed in the status line. However, it is possible to save the study file under a different name than shown in the status line. This is accomplished by selecting the *Save As...* menu choice. When this option is selected, a window exactly like the Open a File window will appear except it will be titled Save a File. From this window, you may type in the new name to save the study file under, or select an existing name from this list of filenames displayed in the columns below.

If the software detects that a file already exists with the same name, it will prompt the user to confirm whether or not to replace the currently existing file. NOTE: When saving a file in this manner, the name of the file in the status line will be updated to reflect the change in the filename.

Deleting a Study

The final file manipulation option available from AHAG software is the ability to delete existing study files. This process is started by selecting the **Delete** menu choice from within the **File** menu. Once selected, a window much like the Open a File window appears except it is titled Delete Files. From this point, files can be selected for deletion. Simply move the cursor to the file to remove and press either the <ENTER> key, or use the mouse to select the [OK] button. The program will prompt with a message for confirmation prior to deleting the file. Select [OK] to confirm the deletion, or select [CANCEL] to abort the delete operation. When finished with deleting the various files, press either <ESC>, or select the [CANCEL] button to return to the File menu.

Printing and Saving Reports

The core of AHAG software is its ability to generate printed output or send output to a file. All data, including the Work Sheet, Field Data, Calculations, and a blank data collection sheet, can be generated. To begin the printing procedure, select the **Print** menu option within the **File** menu. This will open up a new menu with the four options for printing: Work Sheet, Field Data, Calculations, and Field Sheet. The first three reports simply print the data that can be viewed while in the software. However, the Field Sheet is a blank data collection sheet that is based upon the Field Data defined in the study. This report is essentially the Field Data report without the data values printed. This output can then be used in the field to collect data for input into the computer at a later time.

From this next menu, select the report to be generated. When selected, the computer will prompt for the destination of the report, either the printer or a file. If the printer is selected, the output will go directly to the printer. If a file is selected, the computer will prompt for the name of the file in which to save the information. This file will be located in the Reports directory specified in the System Defaults (See Chapter 6 for more information). The AHAG software does not require the user to specify any particular extension for these report filenames, nor does it append a default extension to the filename. This is left up to the user's discretion.

Exiting AHAG

To exit the AHAG program and return to the DOS session, you must select the *Exit* menu choice from the *File* menu. When this is selected, the program will prompt with a message box asking for confirmation of this action. Select the [OK] button or press <ENTER> to finish exiting the program; otherwise, select [CANCEL] or <ESC> to return to running the AHAG program. When exiting AHAG, the software will prompt the user with a message box asking to save the current working session in memory. If [YES] is chosen, then the user will be presented with the familiar save dialog box where the filename may be changed or kept and the session can be saved.

6 AHAG Edit Menu

The AHAG *Edit* menu provides access into three main areas of data input: Study structure definition, Histogram and Graph development, and Field Data input. The *Edit* menu provides individual access into each of these three areas of an AHAG study. The first is the *Definitions*, which is the study structure definition. The second menu choice is the *Work Sheet*. It is in the work sheet where the functional relationships between Habitat Variables, Species, and Life Stages are created. Finally, the last menu choice gives access to the variables or *Field Data* defined in the definition of the study.

Editing Definitions

The first step in creating an AHAG study is to define the structure of the study file in terms of Habitat Variables, Species, and Life Stages. Remember to first create a new study by selecting the *New* menu choice in the *File* menu and typing in a study filename. To begin this process, select the *Definitions* menu choice from within the *Edit* menu. Once this choice is made, the program will present a new screen titled Definitions (See Figure 4). It is from this editor that the changes to the study structure are made.

There are three major areas that can be edited at this point: Habitat Variables, Species, and Life Stages. To switch between the two windows, use the <TAB> key or press the primary mouse key on the window to edit in. The life stages are accessed by using the right arrow key when a particular species is currently highlighted.

To increase the number of items in the screen, press the <INSERT> key; to remove an item, press the <DELETE> key with the highlighted cursor on the desired selection to delete. For example, to increase the number of habitat variables, move the cursor to the desired position to insert; then press the <INSERT> key, and a place will be created for a new Habitat Variable. Refer to Chapter 4 and the section on Editing Text and Data for information on changing names of items in this screen.

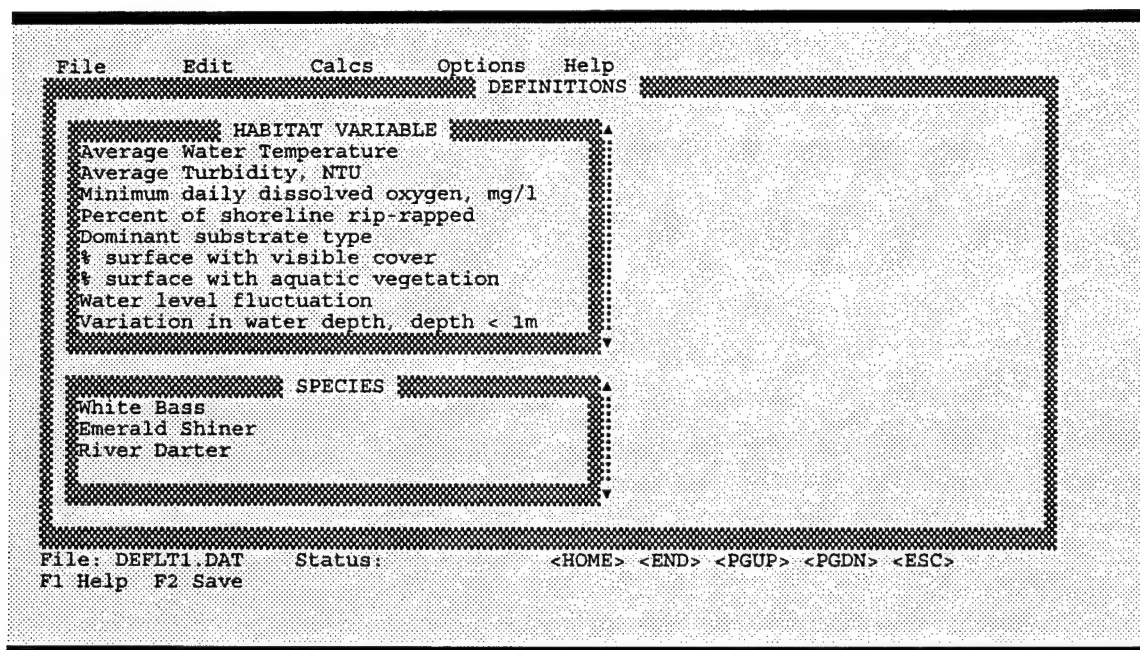


Figure 4. Example of Definitions screen

Here is a list of the numbers of items that can be input in the Definitions:

- 30 Habitat Variables.
- 3 Species.
- 5 Life Stages per species.

Editing Work Sheet

Once the structure of the study has been defined, the mathematical structure of model calculations is determined by selecting the *Work Sheet* menu choice from within the *Edit* menu. After this choice is made, the program will present a new screen that resembles a spreadsheet. This screen contains the structure of the study as defined in the Definitions section of the program. See Figure 5 for an example of this screen.

Species and Life Stage are listed across the top of the work sheet, and Habitat Variables are listed down the left-hand side. The rows and columns of data located within this matrix are the individual calculation cells used to compare against the Field Data for generating the calculations. The cells can be either a Histogram or a Graph. The type of cell is noted by using GRAPH to identify a Graph type and HIST to identify a Histogram type. Each of these cells must be individually edited. To edit one of these cells, position the

File Edit Calcs Options Help						
SPECIES & LIFESTAGE HABITAT VARIABLE	White Bass			Emerald Shiner		
	Spawnin	Rearing	Juvenil	Spawnin	Rearing	Juvenil
Average Water Temperature	HIST	HIST	HIST	HIST	HIST	HIST
Average Turbidity, NTU	HIST	HIST	HIST	HIST	HIST	HIST
Minimum daily dissolved oxyge	HIST	HIST	HIST	HIST	HIST	HIST
Percent of shoreline rip-rapp	HIST	HIST	HIST	HIST	HIST	HIST
Dominant substrate type	HIST	HIST	HIST	HIST	HIST	HIST
% surface with visible cover	HIST	HIST	HIST	HIST	HIST	HIST
% surface with aquatic vegeta	HIST	HIST	HIST	HIST	HIST	HIST
Water level fluctuation	HIST	HIST	HIST	HIST	HIST	HIST
Variation in water depth, dep	HIST	HIST	HIST	HIST	HIST	HIST
Variation in water depth, dep	HIST	HIST	HIST	HIST	HIST	HIST
% area with water depth > 1m	HIST	HIST	HIST	HIST	HIST	HIST
% year/season contiguous back	HIST	HIST	HIST	HIST	HIST	HIST
Average water velocity	HIST	HIST	HIST	HIST	HIST	HIST
Average depth of thalweg	HIST	HIST	HIST	HIST	HIST	HIST

File: NEW.DAT Status: <HOME> <END> <PGUP> <PGDN> <ESC>
F1 Help F2 Save F4 Cell Type

Figure 5. Example of Work Sheet screen

highlighted cursor on the desired items and press <ENTER>. When this is done, the appropriate editor for the cell type will be invoked, either a Histogram or Graph editor.

While editing the Work Sheet, it is possible to selectively omit a Habitat Variable from the final calculations for an individual Species and Life Stage. This is accomplished by moving the highlighted cursor to the desired Species and Life Stage and then press the <SPACEBAR>. This will toggle the current status of that particular cell. An asterisk (*) will appear just to the left of the cell type designation (either *HIST or *GRAPH) if the cell is to be omitted from the calculations. Otherwise, no asterisk will appear if the cell is to be used in the calculations.

Each cell type can be transformed to the other type. Press the <F4> function key to open up a pop-up menu containing the choices for cell type, either Histogram or Graph. Select the appropriate cell type and press <ENTER>. The cell will now reflect the change within the matrix.

Histogram Editor

As its name implies, the histogram editor is used only to edit the data contained within a histogram. When this editor is started, a screen titled Histogram Editor is displayed containing the associated Habitat Variable,

Species, and Life Stage for the matrix component. Figure 6 shows an example of this screen.

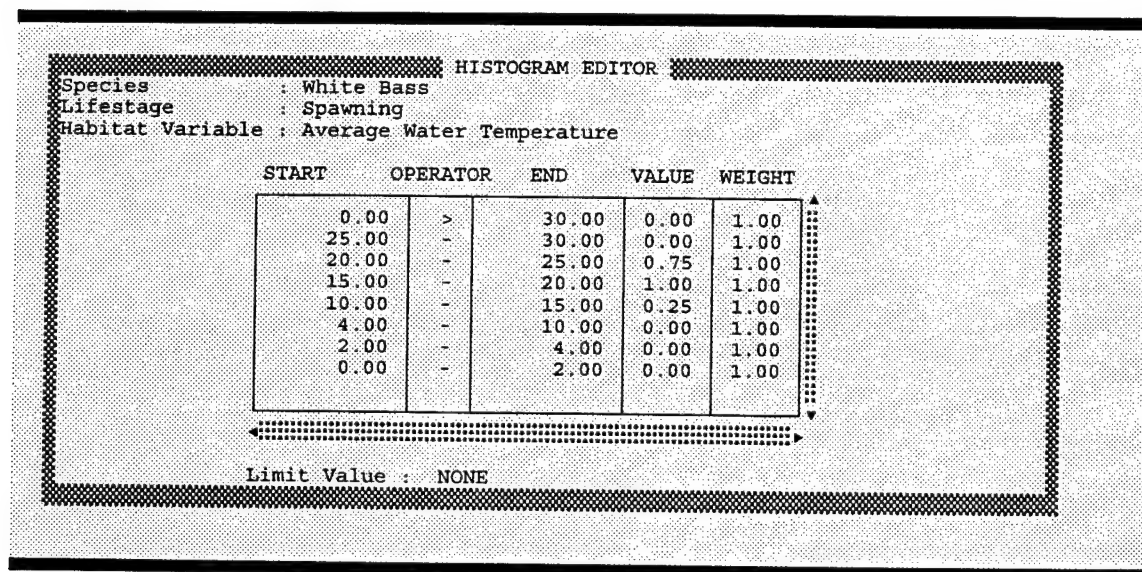


Figure 6. Example of Histogram Editor screen

From within this editor, all of the data associated with the individual histogram can be edited. There are five different sections to each row in the histogram. The first three define the shape of the histogram. The Start column identifies the first value in the individual histogram bin. The End column identifies the last value for the individual histogram bin. The Operator defines the behavior to use when the model is computed during the calculations. The following demonstrates the three operators that can be used.

	Start	Operator	End	Value	Weight
Example 1	0.00	<	0.00	0.10	1.00

This row creates a bin with no width, but is used to describe a lower boundary condition. In the case that the field data value is less than 0.00, the resultant calculation will end up being 0.10.

Example 2	10.00	>	10.00	0.90	1.00
-----------	-------	---	-------	------	------

This row also creates a bin with no width, but is used to describe an upper boundary condition. In the case that the field data value is greater than 10.00, the resultant calculation will end up being 0.90.

Example 3	1.00	-	3.00	0.20	1.00
-----------	------	---	------	------	------

This row creates a bin that represents a range encompassing 1.00 up to but not including 3.00. When the field data falls into this range, the resultant calculation will end up being 0.20.

Example 4	1.00	-	1.00	0.50	1.00
	2.00		--	2.00	1.00

This example represents when numeric results are not derived, but descriptive values such as substrate type are used. For this example then

1.00 = silt with a value of 0.5
 2.00 = gravel with a value of 1.0

The Value column is the HSI value used in calculations. The final column in the histogram editor is the Weight value used to increase or decrease the relative importance of an individual calculation. This weight is set to a default of 1.00 so that no change in the overall calculation is made. A higher weighting value indicates increased importance of the variable in the overall calculations; the weight value should decrease to reflect a lower importance. Note that there is an upper limit of 20 rows of histogram data for each individual histogram.

There is a limit value associated with each histogram cell in the matrix that is accessed by pressing the <TAB> key while editing rows of the histogram. By default, the limit will show a value of "NONE" to signify no limit used in the calculations. If you have previously defined a limit for a histogram, it can be removed by pressing the <F5> function key. For more information on limiting values, please refer to Chapter 1.

Graph Editor

As its name implies, the graph editor is used only to edit the data contained within a graph. When this editor is started, a screen titled Graph Editor is displayed containing the associated Habitat Variable, Species, and Life Stage for the matrix component. Figure 7 shows an example of this screen.

From within this editor, all data associated with the individual graph can be edited. There are two sections to each row in the graph. The first column is the X position on the graph, and the second column is the Y position on the graph. Note that AHAG software linearly interpolates between points when generating calculations. Also, there is an upper limit of 20 points for each individual graph.

To see a computer graphics representation of the graph, press the <F10> function key. To exit viewing the graph, press the <ESC> key; the graph editing screen will reappear, and data points can continue to be added or edited.

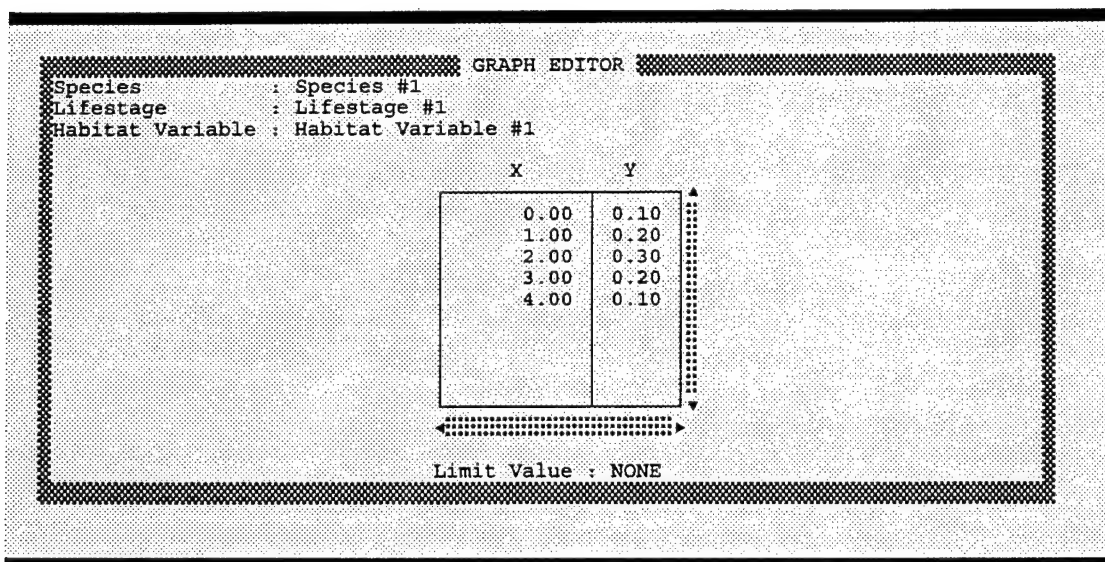


Figure 7. Example of Graph Editor screen

There is a limit value associated with each graph cell in the matrix that is accessed by pressing the <TAB> key while editing rows of the graph. By default, the limit will show a value of "NONE" to signify no limit defined for use in the calculations. If you have defined a limit for a graph, it can be removed by pressing the <F5> function key.

Editing Field Data

After the model has been completely defined in terms of both physical and mathematical structure, the model is ready to produce some outputs. However, the data collected in the field and projected for future events must be entered before results of the calculations can be seen. The process is started by selecting the *Field Data* menu choice from within the *Edit* menu. Figure 8 shows an example of how this screen looks.

There are two parts to editing field data. The first is to fill in the header data associated with the AHAG study. The second is to fill in the individual values for Target Years and Habitat Variables. By default, you are placed into editing the header information when this screen is first invoked. The <TAB> key can be pressed to toggle between editing header information and individual values.

AHAG software allows the user to load and save individual Field Data sheets into their own files. This can be accomplished only while in the Field Data editor. While the editor is in use, the function keys <F4> and <F5> are used to load and save these individual field data sheets, respectively.

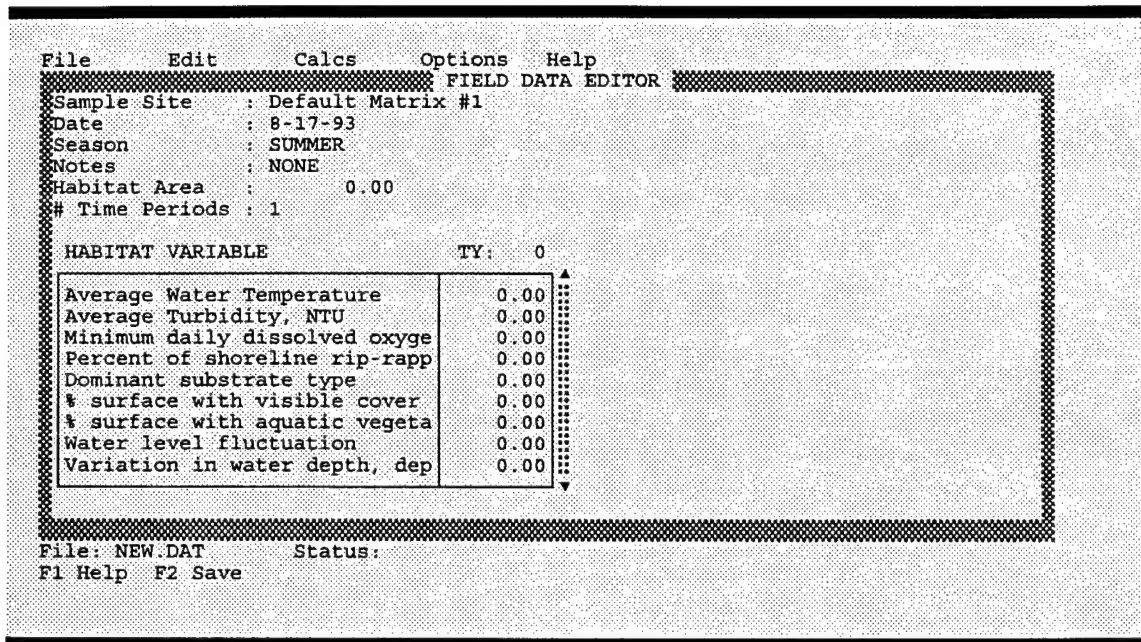


Figure 8. Example of Field Data Editor screen

When these functions are used, the loading and saving dialog box will be the same as that shown during the loading and saving of the entire AHAG study file.

Note that the current field data sheet will be saved when an AHAG study file is saved. Also, when saving AHAG study files, use the extension .DAT; when saving individual field data sheets, use the extension .FDS to differentiate between the two types of files.

Study Header

The study header consists of six main entries in addition to the number of target years identified in the # Time Periods entry. These fields include: Sample Site, Date, Season, Notes, Habitat Area, and # Time Periods. This header is printed out at the top of every report generated by AHAG to identify the study from which data were taken. The Sample Site is the name of the location being studied. The Date is generally the date that the model was created or field data were collected. The Season is the time of year that the model represents (e.g., spring, summer, fall, and winter). The Notes are a single line of data to help identify the study model. The Habitat Area is the area under consideration (i.e., project area) for this model. Finally, the # Time Periods represents the number of Target Years to include in the study (up to a maximum of 5 are allowed). As the # Time Periods field is changed, the AHAG software will automatically update the display to reflect this

change. Target Years can be changed by moving the cursor (using right arrow key) to the individual years and making the appropriate change.

Field Data Values

The field data values are the values of a habitat variable determined from field measurements or predicted for future conditions. The entry form is similar to a spreadsheet similar to the one previously described for the Work Sheet. There is a cell for each Habitat Variable and its associated Target Year. To edit these cell values, use the arrow keys to move the cursor and fill in each field to reflect the measured or predicted data. When completed, press <ESC> to return to the main menu and proceed with viewing the calculations (as described in the next chapter).

7 AHAG Calcs Menu

AHAG software provides quick and easy access to a variety of calculations. HSI values can be calculated from the following choices:

- Arithmetic mean of all variable scores (compensatory relationships).
- Arithmetic mean of selected variables that are considered limiting.
- Taking the single lowest HSI score (limiting factor).

Habitat Units can be calculated for one point in time or annualized for the life of the project, referred to as Average Annual Habitat Units (AAHU) (USFWS 1980).

Calculations are displayed when the *Calcs* menu choice is made from the main menu bar. Each species and life stage is displayed on a single screen at one time. Intermediate and summary calculations are made according to user requirements. This chapter explains specific calculations made by AHAG, how they are generated, how to view the results, and how they can be saved to a file.

Viewing Calculations

Results of the calculations are displayed when you choose the *Calcs* menu option. Each screen of information represents a single Species and Life Stage of the study definition. To switch species and life stages, use the <TAB> key to move forward in the list, and use the key combination of <SHIFT-TAB> to move backwards in the list. As each new Species and Life Stage is switched, the screen will be updated to reflect the respective calculations. Figure 8 shows an example of the calculations screen.

Saving Calculations

Calculations can be saved by two different methods. The first was described in the printing section of this manual (See Chapter 5). The second

CALCULATIONS	
Species : White Bass	Lifestage : Spawning
HABITAT VARIABLE	TY: 0
Average Water Temperature	0.00
Average Turbidity, NTU	0.75
Minimum daily dissolved oxyge	0.00
Percent of shoreline rip-rapp	0.25
Dominant substrate type	0.00
% surface with visible cover	1.00
% surface with aquatic vegeta	1.00
Water level fluctuation	0.00
Minimum HSI.....	0.00
Maximum HSI.....	1.00
Average HSI.....	0.43
AAHU's.....	0.00
Total Acres.....	0.00
Habitat Units.....	0.00

Figure 9. Example of Calculations screen

method is to press the <F4> function key while viewing the calculations. When this is done, the program will prompt for a filename to save the results under. This file will be stored in the Reports directory as defined in the System Defaults (See Chapter 6 for more information). This file will be saved as an ASCII text file that can be loaded into a word processor for further editing. Note that the software does not require any particular filename extension, so the user can choose any filename desired.

Omitting Variables

The AHAG software can selectively omit calculations for certain variables of individual species and life stages. This is accomplished in the Work Sheet editing section of the program. While in this editor, move to an individual cell that represents the habitat variable to be omitted for a species and life stage and press the <SPACEBAR>. When the <SPACEBAR> is pressed, an asterisk (*) will appear to the left of the cell type name. The asterisk indicates that this habitat variable is excluded from the computations for that particular species and life stage. If the <SPACEBAR> is pressed again, the asterisk will disappear and the habitat variable will once again be included in the computations.

While viewing or printing the calculations, note that the AHAG software will place a series of four asterisks (****) in the place of a value if that particular species and life stage was omitted from calculations.

8 AHAG Help Menu

The AHAG software provides access to the on-line help system by two methods: Context Sensitive and the Help Menu. Both of these on-line help aids access the same information but provide different entry points. The Context Sensitive help is available at any time throughout the system by pressing the <F1> function key. The Help Menu is only available by selecting the help topics and using the menu choices in the Help Menu.

Context Sensitive

The Context Sensitive Help is available at any time throughout the AHAG software by pressing the <F1> function key. When this key is pressed, the lower half of the screen opens up as a help window. In the help window, the AHAG software will provide on-line help for the section of the program currently being used. To exit help screens, press the <ESC> key and the program will return to the current program section.

Help Menu

Help index

This menu choice provides an extended list of the various topics of on-line help that are available while using the AHAG software. From the *Help-Index* menu choice, the user can select the specific topic requiring further help.

Help about

The *Help-About* menu choice is a small window that pops up in the center of the screen that tells who wrote the AHAG software and various other credits for the AHAG implementation.

9 AHAG Default Matrix

AHAG has a default matrix of HSI values for eight species of fish that are common in the Upper Mississippi River System. This matrix is not intended to serve as the final model for any particular study. However, they can be used as a starting point and appropriately modified for each study. This chapter describes the development and rationale of the default matrix.

Geographic Area

The default matrix of AHAG was designed for use in the Upper Mississippi River System. The UMRS extends 926 miles¹ from Hastings, MN, southward to Caithersville, MO. Major tributaries include the Missouri and Illinois rivers. To maintain a minimum 9-ft navigation channel, 29 dams were constructed from St. Louis, MO, to Minneapolis, MN (Rasmussen 1979). Most navigation pools are characterized by moderate flow, narrow in the upstream reaches, stable water levels with extensive backwaters in the middle reach, and deep, fluctuating water levels with few backwater areas in the lower reach (Eckblad 1986). Dominant substrate in the Mississippi River and navigable tributaries is sand or clay, and most instream structure consists of wing dams, revetted banks, and fallen trees. Emergent and submersed aquatic vegetation are often found in backwater areas off the main channel. The unregulated reach of the Mississippi River below St. Louis is more turbid than the upper reaches, with swift currents, little instream cover, and few backwater areas.

Evaluation Species

Description of Upper Mississippi River ichthyofauna

Over 140 species of fish have been collected in the UMRS since record keeping began in the late 19th century (Van Vooren 1983). Many of these

¹ A table of factors for converting non-SI units of measurement to SI units is presented on page viii.

species are rare to uncommon because they occur in smaller tributaries of the UMRS, are at the periphery of their range, or have experienced population declines because of water resource development. Excluding these species, a total of 82 species (Table 1) are common or abundant in the Upper Mississippi River and lower reaches of large tributaries (Ohio River, Missouri River, and Illinois River).

These 82 species are dominated taxonomically by minnows (21 species), suckers (12 species), sunfish (10 species), catfishes (8 species), and darters (7 species), which is typical of large alluvial rivers in the Mississippi River Valley (Hocutt and Wiley 1986). Most species maintain reproductive populations in the main stem rivers and associated backwaters, although strays from upland tributaries (e.g., certain minnows and darters), recently introduced species (e.g., hybrid striped bass), and diadromous species (e.g., freshwater eel) also occur.

Selection of evaluation species

A guild is a group of species that exploit the same environmental resources (e.g., habitats) in similar ways (Root 1967). Therefore, members of a guild should be affected similarly by the alteration of those resources (Roberts and O'Neil 1985). A guild matrix was constructed according to habitat preference and reproductive strategy of the species. Habitat and reproduction were considered to be the most appropriate factors for guild development since habitat rehabilitation projects directly alter physical habitat conditions and the objective of most projects is to provide spawning, rearing, and overwintering areas for fishes in the UMRS. The 82 species listed in Table 1 were then segregated within the guild matrix based on a review of available life history data.

There are numerous habitat classifications of the UMRS, but most follow that of Rassmussen (1979), which includes main channel, main channel border, tailwaters, side channels, river lakes and ponds, and sloughs. However, the fish communities are similar among many of these habitats. The guild attempts to avoid this repetition by considering two primary habitat types: lotic and lentic areas. Lotic habitats include swift-water areas such as main channel, main channel border, tailwaters, and open side channels. Lentic habitats include any slack-water areas such as sloughs, river lakes, and ponds. In addition, certain species that were considered ubiquitous and can tolerate a wide range of habitat conditions were assigned to a "generalist" category. Water velocity is assumed to be a major habitat axis along which fish species segregate in environments of large river systems (Leonard and Orth 1988; Baker, Killgore, and Kasul 1991).

Habitat classification was further based on the premise that habitat use varies with size of adult species: small species (< 100-mm total length) and large species (> 100-mm total length). These criteria resulted in the formation of five categories (Table 2): lotic-large fishes (Group 1),

Table 1
Fishes of the Upper Mississippi River and Their Respective Reproduction and Habitat Guild for Juveniles and Adults

Family and Species	Reproduction Guild	Habitat Guild
Petromyzontidae		
Chestnut lamprey (<i>Ichthyomyzon castaneus</i>)	5	1
Silver lamprey (<i>I. unicuspis</i>)	5	1
Acipenseridae		
Lake sturgeon (<i>Acipenser fulvescens</i>)	2	1
Pallid sturgeon (<i>Scaphirhynchus albus</i>)	2	1
Shovelnose sturgeon (<i>S. platyrhynchus</i>)	2	1
Polyodontidae		
Paddlefish (<i>Polyodon spathula</i>)	2	3
Lepisosteidae		
Spotted gar (<i>Lepisosteus oculatus</i>)	3	5
Longnose gar (<i>L. osseus</i>)	3	3
Shortnose gar (<i>L. platostomus</i>)	3	3
Amiidae		
Bowfin (<i>Amia calva</i>)	10	5
Anguillidae		
American eel (<i>Anguilla rostrata</i>)	1	3
Clupeidae		
Skipjack herring (<i>Alosa chrysochloris</i>)	1	1
Gizzard shad (<i>Dorosoma cepedianum</i>)	1	5
Hiodontidae		
Goldeye (<i>Hiodon alosoides</i>)	1	1
Mooneye (<i>H. tergisus</i>)	1	1
Esocidae		
Northern pike (<i>Esox lucius</i>)	3	3
Cyprinidae		
Mississippi silvery minnow (<i>Hybognathus nuchalis</i>)	4	5
Common carp (<i>Cyprinus carpio</i>)	3	5
Speckled chub (<i>Macrhybopsis aestivalis</i>)	1	2
Silver chub (<i>M. storeriana</i>)	1	2
Golden shiner (<i>Notemigonus crysoleucas</i>)	4	5
Emerald shiner (<i>Notropis atherinoides</i>)	1	2
(Sheet 1 of 3)		
Note: The definitions for each habitat and reproduction guild number are found in Tables 2 and 3, respectively.		

Table 1 (Continued)		
Family and Species	Reproduction Guild	Habitat Guild
Cyprinidae (Continued)		
River shiner (<i>N. blennius</i>)	1	2
Ghost shiner (<i>N. buchanani</i>)	4	4
Bigmouth shiner (<i>N. dorsalis</i>)	2	2
Pugnose minnow (<i>N. emiliae</i>)	4	4
Spottail shiner (<i>N. hudsonius</i>)	4	4
Silverband shiner (<i>N. shumardi</i>)	4	2
Sand shiner (<i>N. stramineus</i>)	4	2
Mimic shiner (<i>N. volucellus</i>)	1	2
Red shiner (<i>Cyprinella lutrensis</i>)	4	5
Spotfin shiner (<i>C. spilopterus</i>)	6	2
Blacktail shiner (<i>C. venustus</i>)	6	2
Redfin shiner (<i>Lythrurus umbratilis</i>)	11	4
Bullhead minnow (<i>Pimephales vigilax</i>)	12	5
Bluntnose minnow (<i>P. notatus</i>)	12	5
Fathead minnow (<i>P. promelas</i>)	12	5
Catostomidae		
River carpsucker (<i>Carpionodes carpio</i>)	4	3
Quillback (<i>C. cyprinus</i>)	2	3
Highfin carpsucker (<i>C. velifer</i>)	2	1
White sucker (<i>Catostomus commersoni</i>)	2	1
Blue sucker (<i>Cycleptus elongatus</i>)	2	1
Smallmouth buffalo (<i>Ictiobus bubalus</i>)	3	3
Bigmouth buffalo (<i>I. cyprinellus</i>)	3	3
Black buffalo (<i>I. niger</i>)	3	3
Spotted sucker (<i>Minytrema melanops</i>)	2	3
Silver redhorse (<i>Moxostoma anisurum</i>)	2	1
Golden redhorse (<i>M. erythrurum</i>)	2	1
Shorthead redhorse (<i>M. macrolepidotum</i>)	2	1
Ictaluridae		
Blue catfish (<i>Ictalurus furcatus</i>)	12	3
Channel catfish (<i>I. punctatus</i>)	12	3
Black bullhead (<i>Ameiurus melas</i>)	12	5
Yellow bullhead (<i>A. natalis</i>)	12	5
Brown bullhead (<i>A. nebulosus</i>)	12	3
Stonecat (<i>Noturus flavus</i>)	12	2
Tadpole madtom (<i>N. gyrinus</i>)	12	4
Flathead catfish (<i>Pylodictis olivaris</i>)	12	3
(Sheet 2 of 3)		

Table 1 (Concluded)		
Family and Species	Reproduction Guild	Habitat Guild
Cyprinodontidae		
Blackstripe topminnow (<i>Fundulus notatus</i>)	3	5
Poeciliidae		
Mosquitofish (<i>Gambusia affinis</i>)	13	5
Gadidae		
Burbot (<i>Lota lota</i>)	2	1
Atherinidae		
Brook silverside (<i>Labidesthes sicculus</i>)	4	4
Percopsidae		
Trout-perch (<i>Percopsis omiscomaycus</i>)	4	3
Percichthyidae		
White bass (<i>Morone chrysops</i>)	2	1
Yellow bass (<i>M. mississippiensis</i>)	2	1
Centrarchidae		
Rock bass (<i>Ambloplites rupestris</i>)	9	4
Green sunfish (<i>Lepomis cyanellus</i>)	11	5
Warmouth (<i>L. gulosus</i>)	11	4
Orangespotted sunfish (<i>L. humilis</i>)	11	5
Bluegill (<i>L. macrochirus</i>)	11	4
Longear sunfish (<i>L. megalotis</i>)	11	4
Smallmouth bass (<i>Micropterus dolomieu</i>)	9	1
Largemouth bass (<i>M. salmoides</i>)	11	4
White crappie (<i>Pomoxis annularis</i>)	11	4
Black crappie (<i>P. nigromaculatus</i>)	11	4
Percidae		
Western sand darter (<i>Ammocrypta clara</i>)	4	2
Johnny darter (<i>Etheostoma nigrum</i>)	12	4
Logperch (<i>Percina caprodes</i>)	4	4
River darter (<i>P. shumardi</i>)	4	2
Yellow perch (<i>Perca flavescens</i>)	3	3
Sauger (<i>Stizostedion canadense</i>)	2	1
Walleye (<i>S. vitreum</i>)	2	3
Sciaenidae		
Freshwater drum (<i>Aplodinotus grunniens</i>)	1	1
(Sheet 3 of 3)		

Table 2
Description of Habitat Groups for Fishes of the Upper Mississippi River

Group 1	
Lotic-large fishes	These fish are large (>300 mm), pelagic-oriented species that prefer rather clear, fast-flowing water over a sand or gravel substrate. Most species are migratory, travel in schools, and often constitute an important commercial fishery. Spawning occurs over sand or gravel shoals in the spring. The fry of this group are usually pelagic and move into shallower water as they grow, feeding on plankton and small invertebrates. The adults feed on large invertebrates or fishes.
Group 2	
Lotic-small fishes	This group is mostly comprised of small (<100 mm) minnows and darters. Species in this group are important forage fishes, and their presence generally indicates good riverine habitat. They often travel in schools and occupy similar habitat as described for species in Group 1, but generally occur in shallower water and do not migrate great distances. Reproduction behavior is variable, but spawning usually occurs during the spring over sand or gravel in flowing water. Their diet consists of plankton and small invertebrates.
Group 3	
Lentic-large fishes	This group inhabits slack-water areas seasonally connected to the main stem river. They generally avoid strong current unless traveling between habitats. Because of their large size and relative high abundance, many of these species are important commercial and recreational fish. They often associate with vegetation, woody debris, or other forms of cover in deeper parts of pools, occasionally entering flowing water to feed. Some species are piscivorous as adults, while others, such as suckers and bullheads, feed on mollusks, insects, and plankton. Spawning occurs during the spring and early summer in shallow, non-flowing water over vegetation, logs, or prepared nests. One notable exception is the American eel, which spawns around the Sargasso Sea.
(Continued)	

Table 2 (Concluded)	
Group 4	
Lentic-small fishes	<p>This group of relatively small fish are common in slack-water habitats seasonally connected to the main stem river. They are typically found in shallow, clear to moderately turbid water with little current. Most species associate with some form of submerged cover. Spawning occurs in spring and early summer in shallow water. Sunfish deposit eggs in prepared nests, while others spawn along a sandy or clay substrate without parental care. The young often school and become pelagic, but return to shallow areas with submerged timber or aquatic vegetation as they grow. The fry consume plankton and later small crustaceans and insects. Fish are also eaten, particularly by the adult sunfish.</p>
Group 5	
Generalists	<p>These fishes occur in a variety of habitats and are widespread throughout their range. They can live in slack-water areas that are noncontiguous with the main stem river. Most species in this group tolerate a wide range of environmental conditions, including high turbidity, low dissolved oxygen, and high water temperatures. They are often the first inhabitants of disturbed habitats and can survive in isolated pools, but generally prefer shallow, sluggish waters with vegetation. Most have an extended spawning season throughout the spring and summer over a variety of substrates. Sunfish and bullheads prepare nests and guard the eggs, while others broadcast their eggs with no parental care. Mosquitofish eggs are fertilized internally, and females give birth to living young. The young of this group are usually confined to shallow, protected areas. The diet consists of plankton and invertebrates. Bullheads and sunfish will also consume small fishes.</p>

lotic-small fishes (Group 2), lentic-contiguous-large fishes (Group 3), lentic-contiguous-small fishes (Group 4), and generalists (Group 5). Although there are exceptions, most members of a habitat category share important morphological similarities (e.g., fusiform shape for swift-water fishes and laterally compressed for slack-water fishes) and exhibit the same ontogenetic shifts in preferred habitat (e.g., shallow vegetated areas to open water).

Fishes were also assigned to 1 of 13 reproductive strategies (Table 3) according to modification of the evolutionary classification developed by Balon (1984).

Table 3		
Reproductive Modes of Fishes of the Upper Mississippi River		
		Number
Nonguarders		
Open substratum spawners	Pelagophils (float)	1
	Lithophils (rock and gravel)	2
	Phytophils (plants)	3
	Litho-Psammophils (sand/gravel)	4
Brood hidiers	Lithophils (rocks and gravel)	5
	Speleophils (crevice-spawners)	6
Guarders		
Substratum choosers	Lithophils	7
	Phytophils	8
Nest spawners	Lithophils	9
	Phytophils	10
	Litho-Psammophils	11
	Speleophils	12
Bearers		
Internal Bearers	Viviparous	13
Note: Based on Balon (1984).		

Excluding mosquito fish (*Gambusia affinis*) that are viviparous (see Table 2), guild cells were developed by combining reproduction and habitat classifications resulting in 22 cells (Table 4).

Evaluation species were selected from the guilds to represent commercial, sport, and forage fishes whose life history and ecology are relatively well known, thus allowing documented models to be developed. Selection was by consensus of biologists with the USFWS, U.S. Army Engineer District, Rock Island, Iowa Department of Natural Resources, Wisconsin Department of Natural Resources, and the U.S. Army Engineer Waterways Experiment Station (WES). The evaluation species selected were white bass, emerald shiner, river darter, northern pike, smallmouth buffalo, walleye, largemouth bass, and bluegill. Excluding the generalists group, these eight species represent 77 percent of all fishes that are common to abundant in the UMRS.

Table 4
Reproductive and Habitat Guild of Fish Species of the Upper Mississippi River System

Lotic-Large Fishes	Lotic-Small Fishes	Lentic-Large Fishes	Lentic-Small Fishes	Generalists
Pelagophils				
Skipjack herring Goldeye Mooneye Freshwater drum	Speckled chub Silver chub Emerald shiner ¹ River shiner Mimic shiner	American eel		Gizzard shad
Phytophils				
		Longnose gar Shortnose gar Northern pike ¹ Smallmouth buffalo ¹ Bigmouth buffalo Black buffalo Yellow perch		Spotted gar Common carp Blackstripe topminnow Bowfin
Lithophils				
Chestnut lamprey Silver lamprey Lake sturgeon Pallid sturgeon Shovelnose sturgeon Highfin carpsucker White sucker Blue sucker Silver redhorse Golden redhorse Shorthead redhorse Burbot White bass ¹ Yellow bass Smallmouth bass Sauger		Paddlefish Spotted sucker Walleye ¹	Rock bass	
Litho-Psammophils				
	Bigmouth shiner Silverband shiner Sand shiner Western sand darter River darter ¹	River carpsucker Quillback carpsucker Trout-perch White crappie Black crappie Largemouth bass ¹	Ghost shiner Pugnose minnow Spottail shiner Redfin shiner Brook silverside Warmouth Bluegill ¹ Longear sunfish Logperch	Golden shiner Red shiner MS silvery minnow Green sunfish Orangespotted sunfish
Speleophils				
Blue catfish	Spotfin shiner Blacktail shiner Stonecat	Flathead catfish Channel catfish Brown bullhead	Tadpole madtom Johnny darter	Bullhead minnow Bluntnose minnow Fathead minnow Black bullhead Yellow bullhead
¹ Evaluation species.				

Other species can be chosen from the guilds if they are considered important in a particular project and information on their life history and habitat preferences is sufficiently documented. AHAG can be easily modified to incorporate additional species that represent more of the guild cells, and thus the fish community, or exclude existing species if they do not occur in the study area.

Life history and ecology of evaluation species

Life history information is provided for each evaluation species as a basis for developing HSI scores. This information is not intended to be comprehensive, but rather a cursory description of habitat utilization by the evaluation species. Users of AHAG are encouraged to consider other life history data for a particular species that is pertinent to the geographical area or engineering project and make any necessary modifications to the models. Unless otherwise indicated, life history information was summarized from HSI models published in the Biological Report Series by the USFWS for the following species: white bass (Hamilton and Nelson 1984), northern pike (Inskip 1982), smallmouth buffalo (Edwards and Twomey 1982), walleye (McMahon, Terrell, and Nelson 1984), largemouth bass (Stuber, Gebhart, and Maughan 1982a), and bluegill (Stuber, Gebhart, and Maughan 1982b). For those species without published HSI models (emerald shiner and river darter), descriptions of life history relied on information from Becker (1983), Pflieger (1975), Smith (1979), Trautman (1981), and primary literature.

White bass. White bass are laterally compressed, silvery species common in large rivers and reservoirs. Their weight rarely exceeds 3 lb, and their life span is seldom more than 4 years. They inhabit open water in large rivers with moderate current. White bass are tolerant of moderate turbidity and avoid areas with continuous high turbidity. White bass form large schools and feed near the water surface in early morning and late evening (Pflieger 1975). Adults are usually piscivorous, while juveniles consume small crustaceans and insects. White bass production is high where large populations of forage fish exist (Hamilton and Nelson 1984).

White bass reach sexual maturity at 2 to 3 years; males usually mature 1 year earlier than females. Spawning runs occur early in the spring when water temperatures reach 12 to 16 °C. White bass prefer to spawn in running water over gravel substrate, but will also spawn over rocks in lentic environments. Fertilized eggs sink and stick to gravel, rocks, or vegetation. Adults return to deeper water immediately after spawning. White bass larvae drift with the currents and eventually move into backwaters or other protected habitats. The young avoid dense vegetation and shallow areas with dense vegetation; they prefer shallow water over sandy beaches (Becker 1983).

Emerald shiner. Emerald shiners are common inhabitants of large lakes and rivers in the UMRS and are an important food for many species of fish. They are a slender, laterally compressed species with a maximum size of

about 95 mm and have large eyes (Douglas 1974). Emerald shiners are usually found in open channels having low to moderate velocities and in a wide range of turbidities and bottom types. There is no decided preference for structure such as logs and aquatic vegetation. Emerald shiners are a schooling species that live in midwater during the day and often come to the surface at night to feed. They feed by sight on small invertebrates: crustaceans in lentic habitats (Ewers 1933; Fuchs 1967) and aquatic and terrestrial insects in lotic environments (Mendelson 1975; Whitaker 1977).

Emerald shiners reach sexual maturity within 1 year and live no longer than 3 years (Fuchs 1967). Spawning begins late in the spring when water temperatures reach 22 °C and continues through July or August. They spawn at night in large schools. Nonadhesive eggs are deposited over sand, gravel, or firm mud in depths of 2 to 6 m with slow to moderate velocities. The eggs sink to the bottom and hatch in 24 to 36 hr. The fry gather in schools in the open water of lakes and in the pools of rivers.

River darter. River darters are the most common species of darter in the Mississippi River (Kuehne and Barbour 1983; Page 1983). They are demersal fish that inhabit moderate to fast current over rocks or gravel in medium to large rivers (Page 1983). River darters are extremely tolerant of high turbidity (Kuehne and Barbour 1983). Adults are usually found in waters greater than 1 m; juveniles can occur in water shallower than 0.5 m (Kuehne and Barbour 1983; Thomas 1970). Adults and juveniles eat snails, midges, and caddisfly larvae (Thomas 1970).

River darters reach sexual maturity at age 1 and can live at least 3 years (Thomas 1970). They spawn in April or May, although earlier spawning is possible in the southern part of their range (Kuehne and Barbour 1983). Like most darters, the males exhibit courting behavior prior to spawning. They spawn over rubble, gravel, or sand in depths less than 1 m in areas of strong current (Kuehne and Barbour 1983).

Northern pike. This species has a duck-bill shaped snout and a large mouth with many sharp teeth (Pflieger 1975). Northern pike are an important sport fish in the UMRS. Missouri is on the southern edge of the range for this northern species (Pflieger 1975). Northern pike occur in backwaters and pools, avoid strong currents, and prefer areas with dense aquatic vegetation. They can tolerate low temperatures if dissolved oxygen is adequate; thus they are considered a cool-water species. Northern pike travel extensively, often moving between backwaters in response to low dissolved oxygen, fluctuating water temperatures, or to avoid overcrowding (Becker 1983). Northern pike become piscivorous early in life, but feed opportunistically on seasonally abundant food resources.

Northern pike reach sexual maturity in 1 to 3 years. They spawn in March or April as soon as the ice begins to break up in the spring (Becker 1983). Eggs are deposited over vegetation in shallow water. Newly hatched larvae adhere to vegetation by using a sucker-type membrane on the top of the head

(Becker 1983). Fry emigrate from spawning areas when they are 15 to 20 mm long. Growth of northern pike is rapid, and they can exceed 10 lb and usually live about 10 years.

Smallmouth buffalo. Smallmouth buffalo are important commercial fish in the Mississippi River drainage. They are suckers with a heavy head and a robust body (Douglas 1974). This riverine species occurs in deep, flowing water, but also frequents low-velocity areas such as sloughs, oxbow lakes, and other backwaters for resting, spawning, and rearing areas (Kallemeyn and Novotny 1977). Buffalo can grow well in and tolerate turbid waters. Smallmouth buffalo feed by searching the bottom for small crustaceans, snails, insect larvae, as well as algae and certain species of aquatic plants (McComish 1967; Clay 1975). Young buffalo gather in shallow bays and feed primarily on zooplankton and chironomid larvae.

The age of sexual maturity is variable, but mature individuals weigh approximately 450 g and are age 2 to 6 (Walburg and Nelson 1966). Spawning coincides with rising water levels during the spring at temperatures from 19 to 27 °C, peak spawning from 22 to 26 °C (Jester 1973). Adhesive eggs are scattered over all bottom types in slack-water areas at depths of 1.2 to 2.4 m, but spawning adults prefer substrates of recently inundated vegetation and other submersed objects (Jester 1973). The eggs are left unattended by the adults, and incubation takes 4 to 12 days at 14 to 21 °C (Walburg and Nelson 1966). The fry prefer warm, shallow, backwaters (<20-cm/sec velocity) and mud bottoms (Kallemeyn and Novotny 1977).

Walleye. Walleyes are one of the most important game fish in North America. They occur in loose aggregations in moderate to large lake and river systems. They prefer areas with clear water, cool temperatures, shallow to moderate depths (<15 m), and substrates of sand, gravel, rubble, and boulders. Walleyes are sometimes found in slight currents except during the winter when they avoid turbulent areas. Adults are found in deeper waters during the day and move inshore at night to feed. The diet of juveniles and adults consists primarily of fish. Walleye fry eat zooplankton and aquatic insects.

Male walleyes reach sexual maturity at approximately 5 years, while females mature at about 7 years. Walleyes spawn at night during the spring shortly after ice breakup at temperatures ranging from 6 to 11 °C. Adhesive eggs are scattered over gravel, boulders, and sometimes vegetation in shallow water. There is no nest preparation or parental care. Hatching occurs in about 7 days at a temperature of 15 °C. Fry move to slack water where zooplankton is abundant for feeding.

Largemouth bass. Largemouth bass are important recreational fish in the UMRs. They have slightly compressed bodies and large mouths with pointed teeth positioned in brushlike pads on both upper and lower jaws (Douglas 1974). Like most centrarchids, largemouth bass occur in slow-moving water (<20 cm/sec) with soft bottoms and abundant cover (40 to 60 percent) in the

form of aquatic vegetation, logs, brush, or debris (Miller 1975). Largemouth bass prefer clear water and are intolerant of high turbidities ($> 100 \text{ mg}/\ell$ suspended solids) (Muncy et al. 1979; Buck 1956). They move into protected backwaters during the winter months. Largemouth bass juveniles consume mostly insects and small fish, and adults feed primarily on fish and crayfish (Emig 1966; Carlander 1977). Largemouth bass fry feed mainly on microcrustaceans and small insects (Carlander 1977).

Largemouth bass mature and spawn as early as age 1 near the southern limit of their range (Clugston 1964; Smitherman 1975). Spawning begins in the spring when water temperatures reach 16.0 to 22 °C (Becker 1983; Miller and Kramer 1971). The males construct nests usually in shallow (0.3 to 0.9 m), nonflowing water on a wide variety of substrates; gravel is preferred, but any type of firm, silt-free bottom is used. Silty, mucky bottoms are unsuitable (Robinson 1961). Eggs hatch in about 3 to 4 days, and the fry rise from the nest and begin to feed 5 to 8 days after hatching in low-velocity areas associated with cover (Aggus and Elliot 1975). The fry remain in a school as long as 31 days and are guarded all or part of this time by the male.

Bluegill. Bluegill are a deep and slap-sided sunfish with a small mouth (Pflieger 1975). They are widespread throughout the eastern United States and are abundant in the UMRS. Bluegill are a popular panfish and stocked in many areas. This species prefers backwaters of rivers where aquatic plants or other forms of structure are present and is intolerant of continuous high turbidity (Pflieger 1975). They are gregarious, often moving in loose aggregations of as many 20 to 30 individuals (Pflieger 1975). Bluegill are opportunistic feeders consuming zooplankton, aquatic and terrestrial insects, and some plant materials.

Bluegill mature at age 1 or 2 and live 1 to 4 years. They are repeat spawners from spring through summer in water temperature ranging from 17 to 31 °C. Nests are constructed in nonflowing, shallow water over various substrates; gravel or sand is preferred. The male guards the nests until the eggs are hatched. The fry usually avoid currents and remain in the backwater feeding on zooplankton. The growth of bluegills is rapid and they can exceed 1 lb.

Habitat Suitability Index Values

The default matrix is comprised of five types of variables (Table 5): physicochemical, habitat structure, morphometric, hydraulic, and interspersions between habitats. Many of these variables have been identified as important in structuring fish communities in a variety of stream ecosystems (Barnickol and Starrett 1951; Becker 1983; Gorman and Karr 1978; Leonard and Orth 1988; Ross 1986; Smith 1979). Furthermore, they characterize physical changes associated with high sedimentation rates and altered water level regimes that have influenced habitat quality in the UMRS.

Table 5 Description of Habitat Variables Used in AHAG Default Matrix		
Types of Variables	Variable Names	Comments
Physiochemical	Average water temperature Average turbidity Minimum daily dissolved oxygen	These are often referred to as water quality variables. Temporal and spatial variability in values should be considered when quantifying in the field.
Habitat structure	Percent of shoreline riprapped Dominant substrate type Percent of surface area with visible logs, timber, undercut banks, and/or brush Percent of surface area with aquatic vegetation	Intermediate levels of structural complexity is assumed optimum for reproduction, foraging, and predator avoidance. In swift-water areas, cover and substrate are used as velocity refuges and feeding sites. In slack-water areas, cover is used as spawning sites and food production areas. Substrate is important for feeding and spawning.
Morphometric	Variation in water depth Percent of area with water depth greater than 1 m Average depth of thalweg	Variation in water depth provides heterogeneous habitats. Shallow water can hamper movement while foraging or avoiding predators and may be associated with high temperature and low DO.
Hydraulic	Water level fluctuation Average water velocity	Fishes require slack-water areas such as bank indentions for resting, feeding, and spawning. High water velocities hamper fishes' ability to maintain position for an extended period of time resulting in emigration from the area and/or low recruitment because of a lack of spawning and rearing habitat. Water level fluctuation can disrupt spawning.
Interspersion	Percent of year/season backwaters are contiguous with the main stem river Distance to nearest backwater with average water depth greater than 1 m Distance to side channel with permanent water > 2 m and connection to main stem river	Interhabitat spatial relationships are considered to be biologically meaningful to fish that require more than one habitat to complete all life stages.

Most variables in the default matrix can be measured along transects placed at representative sites within the project area. Variables that require averages or percentages can be determined from transect data. Onsite mapping or use of aerial photography can also be used to estimate some variables, including interspersion distances between habitats. Detailed information on measuring each of these variables can be found in Hamilton and Bergersen (1984). The AHAG default matrix includes one additional variable that summarizes overwintering habitat: "Percent of backwater area suitable as overwintering habitat from Nov-May...". This is an example of using only one variable that summarizes multiple conditions necessary to provide suitable habitat during a defined time period.

HSI scores were determined by species and life stage (spawning, larvae, and juvenile/adult) from literature reviews, including "Blue Book HSI Models" published by the USFWS and consensus from fishery biologists in the UMRS for application on a broad geographical scale; biologists were

represented by the USFWS, U.S. Army Engineer District, Rock Island, Iowa Department of Natural Resources, Wisconsin Department of Natural Resources, and WES.

For each evaluation species, the range of habitat values were divided into classes, and an SI score was assigned to each class by life stage. Each class interval was rated as excellent (1), good (0.75), fair (0.5), poor (0.25), or unusable (0) habitat. As stated in Chapter 1, there are no HSI values for some variables. This indicates that the species or life stage does not require this particular habitat variable for survival and growth. HSI values that do not reach 0 (unusable habitat) or 0.25 (poor habitat) indicate that this variable may enhance growth, but is not a necessary requirement for survival of the species or life stage.

Format of AHAG

The AHAG default matrix for the eight evaluation species is shown in Table 6. The format allows the user to conduct separate evaluations of the study area by life stage of the species and for winter, spring, summer, and fall conditions. For example, overwintering habitat of juvenile and adults can be evaluated by selecting only those variables that may limit their survival or abundance during the winter.

Once the evaluation species have been chosen, the basic approach to an evaluation is as follows:

- Select habitat variables that are considered important to abundance and condition or well-being of the species/life stage.
- Make appropriate measurements of the variables in the field or predict the values using consensus or physical models.
- Determine individual HSI scores from the matrix and obtain a final HSI value that rates the habitat quality of the project site. A final HSI score can be obtained using the arithmetic mean of all variable scores, the arithmetic mean of a subset of variable scores, or taking the single lowest HSI score.
- Determine area (e.g., acres) of the project site and multiply by the final HSI value to obtain HUs.
- Compare HUs for each project alternative.

AHAG software can be used to make all calculations and develop summary tables of the results.

Table 6

Default Matrix of the Aquatic Habitat Appraisal Guide

Aquatic Habitat Appraisal Guide-Upper Mississippi River System																																	
Sample Site:		Habitat: Lentic Lotic										Season: Winter, Spring, Summer, Fall																					
Suitability Index Scoring Criteria: Excellent = 1, Good = 0.75, Fair = 0.5, Poor = 0.25, Unusable = 0.0																																	
Habitat Variable		Suitability Index (SI) Score by Species and Life Stage																															
		White Bass				Emerald Shiner				River Darter				Northern Pike				Smallmouth Buffalo				Walleye				Largemouth Bass				Bluegill			
		S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A					
1. Average water temperature, °C		0	0	0.5	0	0.25	0.5	0	0.75	0	0	0	0.75	0.5	1	0.25	0.5	0	0	0.25	0.5	0	0	0.5	0	0.25	0.75						
1. >30		0	0.5	1	0.5	0.75	0.75	1	1	1	1	0	0	0.75	0.5	1	1	1	0	0.25	0.25	0.5	1	0.5	1	1	1						
2. 25-30		0.75	0.75	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	0	0.5	1	1	1	1	1	1	1						
3. 20-25		1	1	1	0.75	1	0.75	1	0.75	1	0.25	1	0.25	1	1	0.5	1	0.25	1	1	1	1	1	1	1	1	1						
4. 15-20		0.25	0.5	1	0.5	0.75	1	0.5	1	0.5	0.5	0.75	0.75	0.5	0.25	0.75	0.75	0.75	0.75	0.75	0.25	0.25	0.5	0.5	0.75	0.75							
5. 10-15		0	0	0.75	0	0.25	0.75	0	0.25	0.75	0.5	1	0.5	0	0.25	0.5	1	0.25	0.5	0	0.25	0.5	0	0.25	0.5	0.75							
6. 4-10		0	0	0.5	0	0	0.25	0	0	0.25	1	0.25	0.25	0	0	0.25	0	0	0.25	0	0	0.25	0	0	0.25	0.5							
7. 2-4		0	0	0.25	0	0	0	0	0	0.25	0.5	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0.25							
8. 0-2		0	0	0.25	0	0	0	0	0	0.25	0.5	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0							
2. Average Turbidity, NTU		0.75	0.75	1	1	1	1	0.5	0.5	1	1	1	1	0.75	0.75	1	0.25	0.5	0.5	1	1	1	1	1	1	1							
1. 0-10		1	1	1	1	1	1	0.75	1	1	1	1	1	1	1	1	1	0.75	1	1	1	1	1	1	1	1							
2. 10-50		1	1	1	0.75	1	1	1	1	1	1	1	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1							
3. 50-100		0.5	0.75	1	0.5	0.75	0.75	0.75	1	0.5	0.5	0.5	0.5	0.75	0.5	0.75	0.5	0.75	0.5	0.75	0.5	0.75	0.5	0.75	0.75	1							
4. 100-150		0.25	0.5	0.75	0.25	0.5	0.5	0.5	0.75	0.5	0.25	0.25	0.25	0.25	0.5	0.25	0.75	0.25	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.75							
5. 150-200		0.25	0.25	0.5	0	0.25	0.25	0.25	0.5	0.25	0	0	0.25	0	0	0.25	0.5	0	0.25	0	0	0.25	0.25	0.25	0.25	0.5							
6. >200		0	0	0	0	0	0	0	0.25	0.5	0	0.25	0	0	0	0.25	0.5	0	0	0	0	0	0	0	0.25	0.5							
3. Minimum daily dissolved oxygen, mg/l		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
1. 0-1		0.0	0.25	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.5	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.0	0.25	0.25	0.25							
2. 1-3		0.5	0.5	0.5	0.5	0.75	0.75	0.5	0.75	0.75	0.5	0.5	0.5	0.5	0.5	0.75	0.75	0.5	0.75	0.75	0.5	0.5	0.5	0.5	0.5	0.75							
3. 3-5		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							
4. >5		0.25	0.5	0.75	1	0.5	0.75	0.5	0.5	0.75	0.5	0.25	0.25	0.25	0.25	0.5	0.25	0.75	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.75							
4. Percent of shoreline riprapped		0.25	0.5	0.75	1	0.5	0.75	0.5	0.5	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							
1. 0		0.25	0.75	1	1	0.75	1	0.75	1	1	0.75	0.75	1	1	0.75	0.75	0.75	0.75	0.5	0.5	0.75	0.75	0.5	0.75	0.5	0.75							
2. 1-10		0.25	0.75	1	1	1	1	1	1	1	1	1	0.25	0.5	1	1	1	0.5	0.75	0.75	0.75	0.75	0.75	0.5	0.75	0.75							
3. 10-25		0.75	1	1	1	1	1	1	1	1	1	0	0.25	0.5	1	1	1	0.75	1	0.75	0.75	0.75	1	0.75	1	1							
4. 25-50		1	1	1	1	1	1	1	1	1	1	0	0.25	0.75	0.5	1	1	0.75	1	0.75	0.75	0.5	1	1	1	1							
5. >50		1	1	1	1	1	1	1	1	1	1	0	0.25	0.5	0.25	1	1	1	1	1	1	0.5	1	1	1	1							
5. Dominant substrate type		0.5	0.5	0.25	0.25	0.75	0.5	0	0.25	0.25	1	1	1	1	1	1	1	1	1	1	1	0.5	0.5	0.25	0.5	0.5							
1. Plants/debris		0.5	0.25	0.5	0.25	0.5	0.5	0	0.25	0.25	0	0.25	0.25	0	0.25	0.5	0.75	0.5	0.25	0.25	0.25	0.25	0.5	0.5	0.75	0.5							
2. Clay/Silt (<1.0 mm)		0.75	1	1	1	1	1	0.5	1	1	1	0.25	0.5	0.5	0.25	1	1	0.25	0.5	0.75	1	1	1	1	1	1							
3. Sand (1-2 mm)		1	1	1	1	1	1	1	1	1	1	0	0.25	0.25	0	1	1	1	1	1	1	1	1	1	1	1							
4. Gravel (2-64 mm)		1	1	1	1	1	1	1	1	1	1	0	0.25	0.25	0	0.75	1	1	1	1	1	1	1	1	1	1							
5. Rocks (>64 mm)		1	0.75	1	1	1	1	1	1	1	1	0	0.25	0.25	0	0.75	1	1	1	1	1	0.25	1	1	1	1							

Suitability Index (SI) Score by Species and Life Stage

White Bass

Emerald Shiner

River Darter

Northern Pike

Smallmouth Buffalo

Walleye

Largemouth Bass

Bluegill

1. Average water temperature, °C

1. >30

2. 25-30

3. 20-25

4. 15-20

5. 10-15

6. 4-10

7. 2-4

8. 0-2

2. Average Turbidity, NTU

1. 0-10

2. 10-50

3. 50-100

4. 100-150

5. 150-200

6. >200

3. Minimum daily dissolved oxygen, mg/l

1. 0-1

2. 1-3

3. 3-5

4. >5

4. Percent of shoreline riprapped

1. 0

2. 1-10

3. 10-25

4. 25-50

5. >50

5. Dominant substrate type

1. Plants/debris

2. Clay/Silt (<1.0 mm)

3. Sand (1-2 mm)

4. Gravel (2-64 mm)

5. Rocks (>64 mm)

(Sheet 1 of 4)

(Sheet 1 of 4)

Table 6 (Continued)

Habitat Variable	Suitability Index (SI) Score by Species and Life Stage																							
	White Bass				Emerald Shiner				River Darter				Northern Pike				Smallmouth Buffalo				Walleye			
	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A
6. Percent of surface area with visible logs, inundated timber, undercut banks, and/or brush																								
1. 0-5	1	1	1	1	1	1	1	1	1	1	1	1	0	0.25	0.25	0.25	0.5	1	1	1	1	1	0.25	0.25
2. 5-10	1	1	0.75	0.75	0.5	0.5	0.75	1	0.75	0.25	0.5	0.5	0.25	0.5	0.5	0.75	0.75	1	1	1	1	0.5	0.25	0.25
3. 10-25	0.5	0.75	0.25	0.5	0.5	0.25	0.25	0.75	0.5	0.75	0.75	0.75	1	1	1	1	1	1	1	1	1	0.75	0.5	0.75
4. 25-50	0.25	0.5	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	1	1	1	1	1	0.5	0.5	0.5	0.75	1	0.75	0.5	0.5
5. >50	0	0.25	0	0.25	0.25	0.25	0	0.25	0.25	1	1	1	1	1	1	0.75	0.5	0.25	0.25	1	1	1	1	1
7. Percent of surface area with aquatic vegetation (lentic habitats only)																								
1. 0-10	1	1	1	1	1	1	1	1	1	1	1	1	0	0.25	0.25	0.25	0.75	1	1	1	1	1	0.5	0.25
2. 10-25	0.75	0.25	0.75	0.75	0.75	0.5	0.5	0.75	0.5	0.25	0.25	0.75	1	1	1	1	0.75	1	1	1	1	0.75	0.5	0.50
3. 25-50	0.25	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.75	1	1	1	1	0.75	0.5	0.5	0.5	1	1	1	1
4. 50-75	0	0	0.25	0.25	0.25	0.25	0	0	0	0	0	1	1	1	1	1	0.5	0.25	0.25	0.25	0.25	0.5	1	0.75
5. >75	0	0	0	0.25	0.25	0.25	0	0	0	0	0	1	1	1	1	0.75	0.25	0.25	0	0.25	0	0.25	0.5	0.25
8. Water level fluctuation																								
1. Stable	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2. Slow rise (0.5-1 m)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3. Rapid rise (1-2 m)	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4. Rapid fall (0.5-1 m)	0	0.25	0.5	0.5	0.5	0.75	0.5	0.5	0.75	0.25	0.25	0.5	0.25	0.25	0.5	0.25	0.25	0.25	0.25	0.25	0.25	0.5	0.5	0.75
9. Variation in water depth, coefficient of variation, percent																								
Mean depth < 1 m																								
1. 0-25	0.25	0.25	0.5	0.75	0.75	1	0.25	0.5	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.75	0.5	0.75	0.25	0.25	0.25	0.5
2. 25-50	0.50	0.75	0.75	1	1	1	0.5	0.75	1	0.75	0.75	0.75	0.5	1	1	1	0.5	1	1	1	0.75	0.5	0.75	0.75
3. 50-100	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4. >100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mean depth > 1 m																								
1. 0-20	0.25	0.25	0.50	0.75	0.75	1	0.25	0.5	0.75	0.5	0.5	0.5	0.25	1	0.75	0.25	1	0.75	0.25	0.25	0.75	0.25	0.25	0.5
2. 20-30	0.50	0.75	0.75	1	1	1	0.5	0.75	1	0.75	0.75	0.75	0.5	1	1	1	1	1	1	1	0.75	0.5	0.75	0.75
3. 30-50	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4. >50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10. Percent of area with water depth greater than 1 m (lentic habitats only)																								
1. 0-10	0	0	0.25	0.5	0.75	0.75							0.5	0.25	0.25	0.25	0.75	0.5	0.25	0.25	0.25	0.5	0.25	0.25
2. 10-25	0.25	0.50	0.50	0.75	1	1							0.75	0.5	0.5	0.5	0.75	0.5	0.25	0.75	0.5	0.25	0.5	0.75
3. 25-50	0.5	0.75	0.75	1	1	1							1	0.75	0.75	1	1	0.5	0.75	0.75	0.5	1	0.75	0.75
4. 50-75	0.75	1	1	1	1	1							1	1	1	1	0.75	1	1	1	1	1	1	1
5. >75	1	1	1	1	1	1							1	1	1	1	0.5	1	1	1	1	1	1	1

(Sheet 2 of 4)

Table 6 (Continued)

Suitability Index (SI) Score by Species and Life Stage																														
Habitat Variable	White Bass				Emerald Shiner				River Darter				Northern Pike				Smallmouth Buffalo				Walleye				Largemouth Bass				Bluegill	
	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A			
11. Percent of year/season backwaters are contiguous with the main stem river (lentic habitats only)	0.75	0.25	0.75	0.5	0.5	0.5																								
	1	0.50	1	0.75	0.75	0.75																								
	1	0.75	1	1	1	1																								
	1	1	1	1	1	1																								
	1	1	1	1	1	1																								
12. Average water velocity, cm/sec	0	1	0.5	0.5	1	0.25	0	0.25	0	0.25	0	1	1	1	1	0.25	1	0.75	1	1	1	1	1	1	1	1	1			
	0	1	0.5	0.75	1	0.5	0	0.25	0.25	0.75	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
	0.25	1	0.75	1	1	1	0.25	0.75	0.75	1	0.25	0.75	0.75	1	1	0.75	0.75	1	1	0.25	0.5	1	0.25	0.5	1	1				
	0.75	0.75	1	1	0.75	1	0.75	1	1	1	0.75	1	0.5	0.75	0.75	0.5	0.5	0.75	1	0	0.25	0.5	0.25	0.5	0.25	0.5				
	1	0.5	1	0.75	0.5	1	1	0.75	1	0.75	1	0	0.5	0.5	0.5	0.5	0.75	0.5	0	0.75	0	0	0.25	0	0	0.25				
	1	0.25	1	0.5	0.25	1	1	0.5	1	0	0.25	0.5	0	0.25	0.5	0.25	0.5	0.75	0.25	0	0.5	0	0	0.25	0	0				
	0.75	0	1	0.25	0.25	0.75	0.5	0.25	1	0.25	0.5	0	0.25	0.25	0	0.25	0.5	0	0.25	0	0	0	0	0	0	0				
	0.25	0	0.5	0.25	0	0.5	0.25	0.25	1	0.25	0.25	1	0	0	0.25	0	0.25	0.5	0	0.25	0	0	0	0	0	0				
13. Average depth of thalweg, m (lotic habitats only)	1	1	0.25	0.5	0.75	0.5	0.75	1	0.75	1	0.75	1	0.25	1	0.25	0.25	0.5	0.25	0.5	0.25	0.5	0.25	0.75	0.25	0.25	0.25				
	1	1	0.75	0.75	1	1	0.75	1	1	1	1	1	1	1	1	0.75	0.5	0.5	0.75	0.5	0.5	0.5	1	1	1					
	0.75	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.75	1	0.75	0.75	1	1	1					
	0.5	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					
14. Distance to nearest backwater with average water depth greater than 1 m, miles (lotic habitats only)	1	1	1	1	1	1																								
	1	0.5	1	1	1	1																								
	0.75	0.25	1	1	1	1																								
	0.5	0.25	1	1	1	1																								
15. Distance to side channel with permanent water > 2 m and year around connection to main channel, miles	1	1	1	1	1	1																								
	1	0.75	1	1	1	1																								
	0.75	0.5	1	1	1	1																								
	0.5	0.25	1	0.5	0.5	1																								
	0.25	0	0.75	0.5	0.5	1																								

Suitability Index (SI) Score by Species and Life Stage

Habitat Variable	White Bass				Emerald Shiner				River Darter				Northern Pike				Smallmouth Buffalo				Walleye				Largemouth Bass				Bluegill	
	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A			
11. Percent of year/season backwaters are contiguous with the main stem river (lentic habitats only)	0.75	0.25	0.75	0.5	0.5	0.5																								
	1	0.50	1	0.75	0.75	0.75																								
	1	0.75	1	1	1	1																								
	1	1	1	1	1	1																								
	1	1	1	1	1	1																								
12. Average water velocity, cm/sec	0	1	0.5	0.5	1	0.25	0	0.25	0	0.25	0	1	1	1	1	0.25	1	0.75	1	1	1	1	1	1	1	1	1			
	0	1	0.5	0.75	1	0.5	0	0.25	0.25	0.75	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
	0.25	1	0.75	1	1	1	0.25	0.75	0.75	1	0.25	0.75	0.75	1	1	0.75	0.75	1	1	0.25	0.5	1	0.25	0.5	1	1				
	0.75	0.75	1	1	0.75	1	0.75	1	1	1	0.5	0.75	0.75	0.5	0.5	0.75	1	0.25	1	0	0.25	0.25	0.25	0.25	0.5	0.5				
	1	0.5	1	0.75	0.5	1	1	0.75	1	0.75	1	0	0.5	0.5	0.5	0.75	0.5	0	0.75	0	0	0.25	0	0	0	0.25				
	1	0.25	1	0.5	0.25	1	1	0.5	1	0	0.25	0.5	0	0.25	0.5	0.25	0.5	0.75	0.25	0	0.25	0	0	0.25	0	0				
	0.75	0	1	0.25	0.25	0.75	0.5	0.25	1	0.25	0.25	1	0	0.25	0.25	0	0.25	0.5	0	0.25	0	0	0	0	0	0				
	0.25	0	0.5	0.25	0	0.5	0.25	0.25	1	0.25	0.25	1	0	0	0.25	0	0.25	0.5	0	0.25	0	0	0	0	0	0				
13. Average depth of thalweg, m (lotic habitats only)	1	1	0.25	0.5	0.75	0.5	0.75	1	0.75	1	0.75	1	0.25	1	0.25	0.25	0.5	0.25	0.5	0.25	0.5	0.25	0.75	0.25	0.25	0.25				
	1	1	0.75	0.75	1	1	0.75	1	1	1	1	1	1	1	1	0.75	0.5	0.5	0.75	0.5	0.5	0.5	1	1	1	1				
	0.75	0.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.75	1	0.75	0.75	1	1	1				
	0.5	0.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				
14. Distance to nearest backwater with average water depth greater than 1 m, miles (lotic habitats only)	1	1	1	1	1	1																								
	1	0.5	1	1	1	1																								
	0.75	0.25	1	1	1	1																								
	0.5	0.25	1	1	1	1																								
15. Distance to side channel with permanent water > 2 m and year around connection to main channel, miles	1	1	1	1	1	1																								
	1	0.75	1	1	1	1																								
	0.75	0.5	1	1	1	1																								
	0.5	0.25	1	0.5	0.5	1																								
	0.25	0	0.75	0.5	0.5	1																								

(Sheet 3 of 4)

(Sheet 3 of 4)

Table 6 (Concluded)

Habitat Variable	Suitability Index (SI) Score by Species and Life Stage																							
	White Bass				Emerald Shiner				River Darter				Northern Pike				Smallmouth Buffalo				Walleye			
	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A	S	R	J/A
16. Percent of backwater area suitable as overwintering habitat from Nov-Feb (no current, water temperature at least 1 °C warmer than main channel, DO \geq 3.0 mg/l, water depth \geq 1.5 m, periodically contiguous with main river channel)																								
1. 0			0.25			0.5							0.25					0.25			0			0
2. 1-25			0.25			0.75							0.25					0.25			0.25			0.25
3. 25-50			0.5			1							0.5					0.5			0.5			0.5
4. 50-75			0.75			1							0.75					0.75			0.75			0.75
5. >75			1			1							1					1			1			1
Calculations																								
Total Score																								
Average HSI Value (total score/number of variables)																								
Minimum HSI Value/1 (Optional)																								
Limiting Factor HSI Score (sum of selected variables/number of variables) (optional)																								
Total Acres																								
Habitat Units (HSI x Total Acres)																								

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Appendix A

Aquatic Habitat Appraisal Guide Software Order Form

Aquatic Habitat Appraisal Guide Software

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13 Fairway Lane, Logan, UT 84321-5961

Utah State University, Logan, UT 84322

U.S. Army Engineer Waterways Experiment Station,
3909 Halls Ferry Road, Vicksburg, MS 39180-6199

U.S. Army Materiel Command Installation and Services Activity,
Environmental Compliance Division, Rock Island, IL 61299-7190